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Review and current status of the aquaculture potential for the Mahimahi, *Coryphaena hippurus*

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Abstract — *The Mahimahi,* **Coryphaena hippurus**, *has excellent potential for aquaculture due to its fast growth (2 kg at 6 months, 9 kg at 1 year), good food conversion efficiency (30 %, wet weight), high fecundity with natural captive spawns (200 000 eggs/female/2 days year round for a 1 year old female), and high price (US$9.00/kg wholesale in Hawaii).*

Using current technology (pelleted feed conversion of 1 :1; feed cost US$1.10/kg; stocking 1.5 fingerlings per m²) 3 crops a year would yield 85 000kg/ha/yr with a potential profit of US$500 000/ha/yr. The status of two commercial ventures is discussed.

The hatchery methods presented here are adequate for pilot-scale production. Hatchery success depends on meeting relatively fastidious dietary and environmental requirements. Optimum turbulence is higher than expected, and food preference is not a valid indicator of optimal diet. Optimum diet is rotifers, d2-d8; copepods, d6-d21; brine shrimp, d10-d25; newly hatched mahimahi larvae, d18-d40; wean to non-living food, d25-d35.

From first feeding through day 40, larvae gain 20 % body weight per day with a food conversion efficiency of 0.3 at ambient Hawaii temperatures (23 to 26°C).

INTRODUCTION

Mahimahi is an excellent candidate for aquaculture and stock enhancement programmes because of its high price ($5-$12/kg to the fisherman), high demand, foreign trade deficit (90 % comes from Taiwan), decline in catch per unit effort, fast growth rate (4-5 pounds at six months), and good (30 %) food conversion efficiency. The growth rate and food conversion efficiency of mahimahi far exceeds that of the yellowtail jack, *Seriola lalandei dorsalis*, (0.4-0.8 pounds at six months, 12 % f.c.e.) when cultured under identical conditions (Kraul, 1985). Similar jacks, *S. quinqueradiata*, are the most profitably cultured marine fish in the world (Matsusato, 1984). Stock enhancement of marine fishes is still in developmental stages, but mahimahi is among the most likely species to succeed (Polovina, 1986). Hawaii's nutrient-poor waters (Hirota et *al.*, 1980) and strong offshore currents probably limit larval survival and recruitment of pelagically spawning fishes. Stock enhancement might have significant impact in this recruitment limited fishery. Mahimahi have a two months hatchery phase to 10 cm FL, and reach minimum market size (2.3 kg) four months after release (Uchiyama et *al.*, 1986). Projected natural mortality over this period is less than 50 %, based on Pauley's (1979) empirical relationships, so chances of successful enhancement are good. If salmon grew as fast as mahimahi (i.e. returned after 4 months instead of 12) but still had the same monthly mortality rate, salmon releasers might get 22 % tag return instead of 1 %. The major limit to beginning enhancement and grow-out studies is the lack of a dependable supply of fingerling mahimahi.

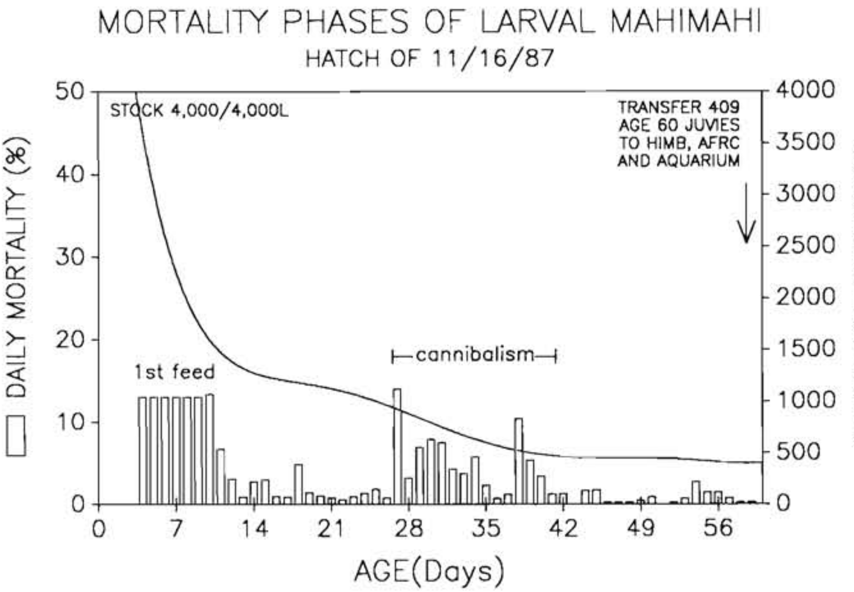


Figure 1. — Typical mortality phases of larval mahimahi, hatch of 11/16/87. Solid curve tracks number of survivors. Vertical bars show daily percent mortality.

BACKGROUND

Since the observation of the mahimahi's frequent natural spawnings in captivity (Soichi, 1978), and the development of techniques for rearing the larvae (Hassler and Rainville, 1975), several projects have reared a small number of fish from eggs through sexual maturity, and discovered good and bad features of this fish. Hagood et *al.* (1981) observed a 33 % wet weight food conversion (equivalent to 0.6 :1 dry food :wet fish) efficiency for juvenile fish. Szyper et *al.* (1984) found that juveniles grew well on a commercially available diet. Schekter (1982) successfully reared 165 F2 juveniles, but experienced inconsistent larval production.

In previous years, research at the Waikiki Aquarium found : survival of yolksac larvae was improved with heavy turbulence; first feeding larvae survived better using rotifers as a first food (despite a preference for copepods); second and third week larvae survived better using copepods instead of rotifers or brine shrimp (Kraul et *al.*, 1989); and postlarval mortality was closely associated with microbial and nutritional changes during weaning from live plankton.

We currently obtain about 20 % hatchery survival to day 30, and 10 % survival through day 6 (Figure 1). By 60 days, juveniles are capable of consuming chopped squid or pellets, and probably large enough for ocean release trials. Hatchery yields of 10 % (one 60-days juvenile per 10 litres) are adequate for testing pilot scale tagging and growout economics, and represent state-of-the-art technology (the « industry » standard is 1 %). Higher yields are being tested for stock enhancement and profitable aquaculture. Our tests at higher stocking densities are compromised by limited amounts of our reference diet, i.e. copepods and yolk-sac mahimahi. Unfortunately, successful weaning of juveniles onto nonliving foods presently requires access to these live plankters from days 6 to 30.

CURRENT HATCHERY PROBLEMS AND RESEARCH

To improve hatchery production, we are attempting to find alternate foods, and learning to diagnose and control diseases. Our successful diet demonstrates that we can achieve nutritional adequacy with live foods, but we need an effective pelletized food in order to reduce hatchery costs and make production more dependable. We also need more studies of bacterial pathogenicity.

In our tests to date, mass cultured brine shrimp has not supported good larval survival, possibly due to a lack of appropriate HUFAs (highly unsaturated fatty acids). The hatchery yield limit imposed by copepod culture (days 6-25) and yolksac larva production (days 18-30) might be bypassed by using *Artemia* spp. (brine shrimp) nauplii enriched with nutritional supplements. This method is useful for other fishes (Gatesoupe, 1982), and is being tested on mahimahi at the Aquarium and other facilities.

Non living foods are often rejected by mahimahi less than 30 days posthatch, and those we have tested appear to be nutritionally deficient. We obtain good survival by avoiding weaning from live foods until day 30. Use of yolksac mahimahi as a food for postlarval mahimahi from day 18 to 30 has been very successful, but depends on a large and consistent supplies of mahimahi eggs. We have not tested this method sufficiently to determine its cost in mass culture. With our successful live diet as a reference, we are defining the nutritional requirements of young mahimahi. Professor Harry Ako, University of Hawaii Agriculture Biochemistry Department, is measuring fatty acid, amino acid, and phospholipid profiles of our successful live diet. These profiles are then used to synthesize pellets. These foods are then tested for ingestion response (the limiting factor in all foods tested so far) and survival. Preliminary results are encouraging. As shown in Figure 2, and Table I, some pelleted foods promote survival and growth of mahimahi juveniles. Both Noraqua and Southern Sea Farms are presently using fish-meal-based pellets with some success.

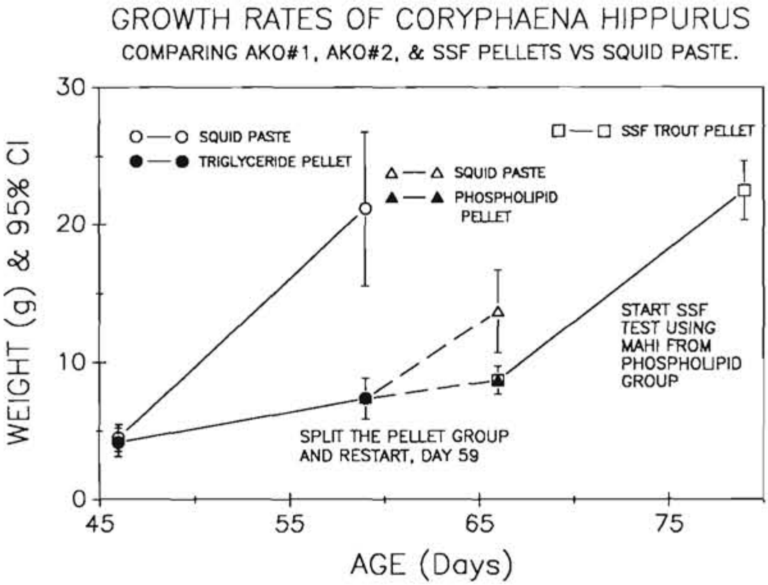
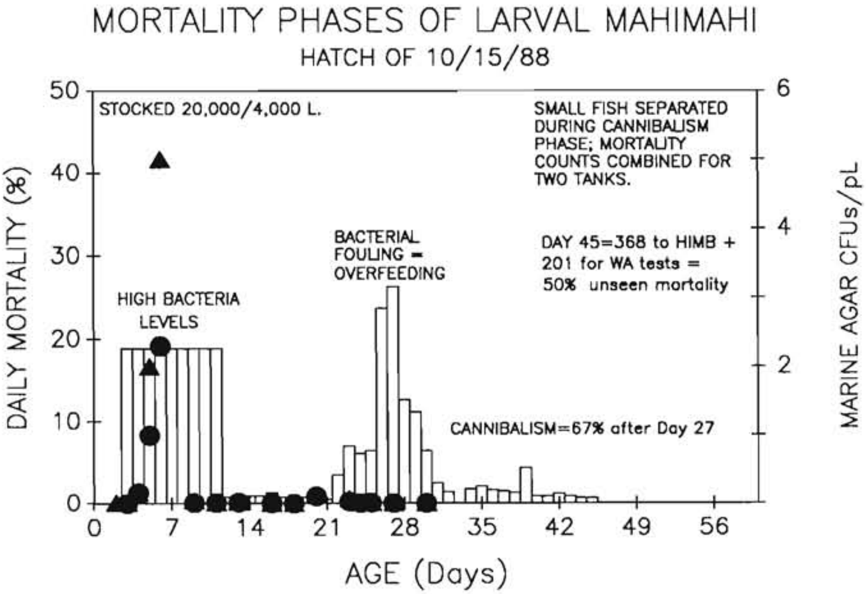


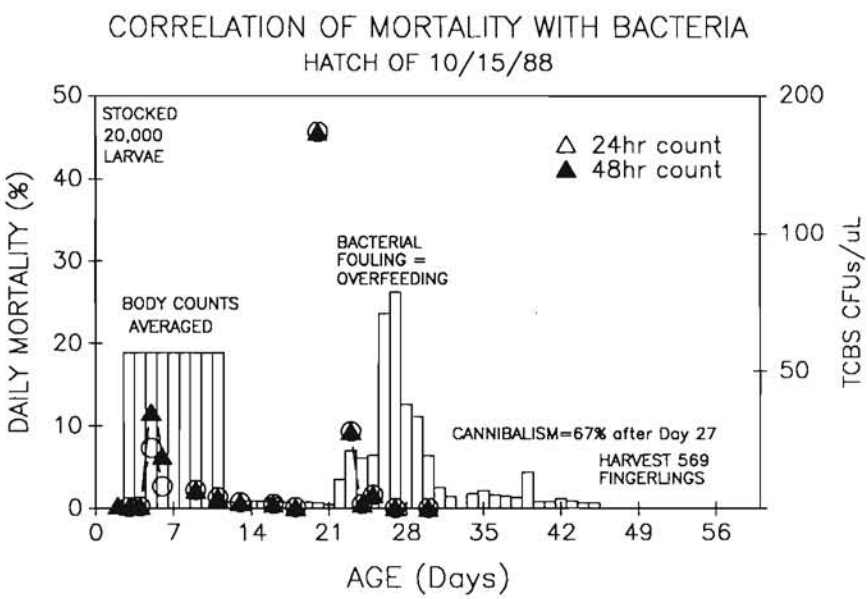
Figure 2. — Growth rates of mahimahi, using pelleted feeds.

Tab. 1. — Growth rates of *Coryphaena hippurus*, comparing 3 trial pellets versus squid paste. See Figure 2 : preliminary conditions were not equal for all tests

	SQUID	AKO≠1	AKO≠2	SSF TROUT
Percent survival	86	76	64	90
Daily % Wt. gain	12.6	4.2	0	7.6
FCE	.21 w/w	.11 w/d	−.02	0.62 w/d
FCR	4.8 w/w	9.3 d/w	−58	1.6 d/w

Bacteria significantly affect larval survival. Our most successful rearing method specifies Prefuran treatment of all live foods. All of the live foods we use successfully now were unsuccessful for five years. We attribute our recent successes to prophylaxis and antibiotic treatment. We have isolated one bacteria type (*Pasteurella* sp.) associated with mortalities, discovered its antibiotic sensitivity (it is Prefuran resistant), and partly tested therapeutic responses of antibiotics. Vibrio species occasionally correlate with larval mortality, and it is quite likely that other bacteria are also pathogenic. Our goal is to prevent disease outbreaks with good hygiene, and to be able to respond to disease organisms with specific antibiotics when necessary. Larval mortality does not always correlate with bacterial density (Figure 3a, b, c). However, some mortalities do correlate, and non-nutritional disease is the only theory that explains the variability in our mortality during the past 6 years (Figure 4).





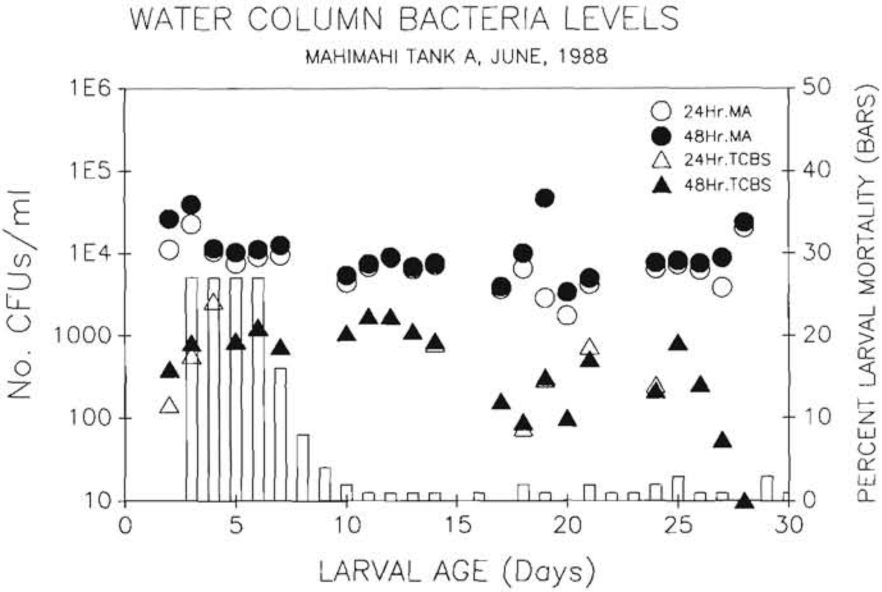


Figure 3. — 3a. Mortality phases of larval mahimahi.
3b. Correlation of larval mortality with suspended bacteria.
3c. Water column bacteria level.

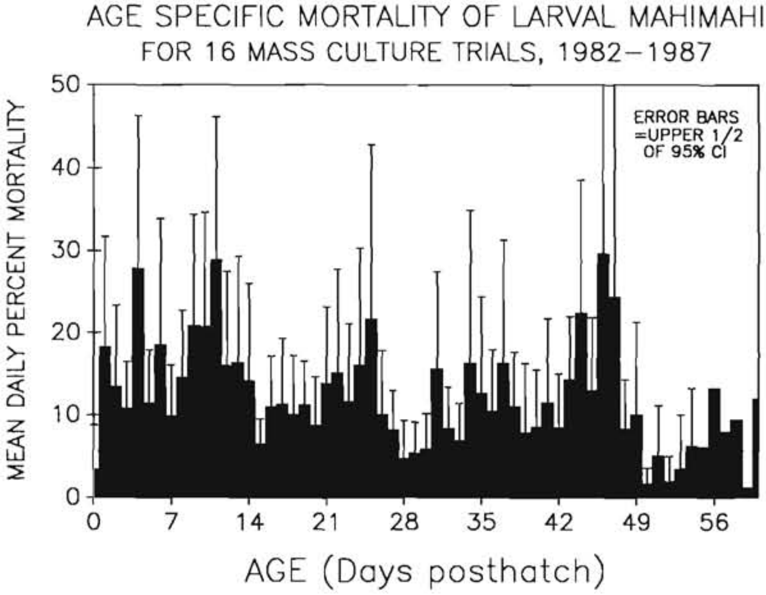


Figure 4. — Variability in larval mortality with age.

HATCHERY METHODS

The following material is condensed from the CRC Handbook of Mariculture, Volume II : Finfish (in review).

Water requirements

We use up to 250 lpm of sea water (SW), which is 1 % of the volume of our tanks each minute. Most of this goes to our broodstock tank, where adult biomass can be 100kg/10m^3 (100 fish, 1 kg each per 20 m^2 $\times$ 0.5 m deep). Mahimahi are very sensitive to dissolved oxygen : Levels above 6 ppm should be maintained; mahi are stressed below 5 ppm. Salinities of 15 to 35 ppt are acceptable, and preliminary results show that levels below 5 ppt may also be acceptable. Temperatures of 13 to 28°C have not killed adult mahimahi, but growth slows below 25-27°C.

BROODSTOCK HUSBANDRY

Adult mahimahi can be purchased from fishermen, who use barbless hooks and a large live well. Fish survive capture best if they are less than 45 cm FL. Transport methods for adult mahimahi have been mastered by Southern Sea Farms, Inc. of Western Australia.

Postlarvae can be dip-netted from flotsam on windward shores of Oahu, or from floating debris and sargassum. The most dependable way to get broodstock is to raise them from eggs. Homegrown breeders have no parasites, and are adapted to tanks. Important factors in maintaining healthy, productive broodstock are water quality, food quality, tank design, and tank cleaning.

Mahimahi can turn in a very tight circle, and a few large adults have been kept alive a few months in a rectangular tank in Okinawa. However, broodstock survive much longer in circular tanks. The best tanks have a central barrier to force the fish to swim around the outside, rather than cut straight across and smash into a perpendicular wall. We still lose a few 1-3 lb. fish, but have kept broodstock healthy and spawning through 15 months (9.5 months of daily spawning).

An all-fiberglass 6.6 m doughnut style tank needs only 5-10 minutes cleaning per day. In our outdoor system, we transfer adults to the inner tank every 2 weeks, by raising the water level and baiting or crowding them through a mid level door. The outer tank is then drained and cleaned with sodium hypochlorite. Cleaning schedule varies with temperature, sunlight, amount of feed, and nutrient load. Uncleaned tanks endanger broodstock survival, especially when eggs and sperm are in the water (i.e. every day), and especially if incoming water stops flowing, or contains nutrients.

Female mahimahi spawn at the Aquarium every other day throughout the year. First spawnings yield 15000-30000 eggs per female. Female growth rate slows at maturation because they discharge 5 % of their body weight as eggs every spawning. By the time males are 15 kg. (15 months or less), captive females are 4.5 kg, and produce at least 200 000 eggs every 2 days.

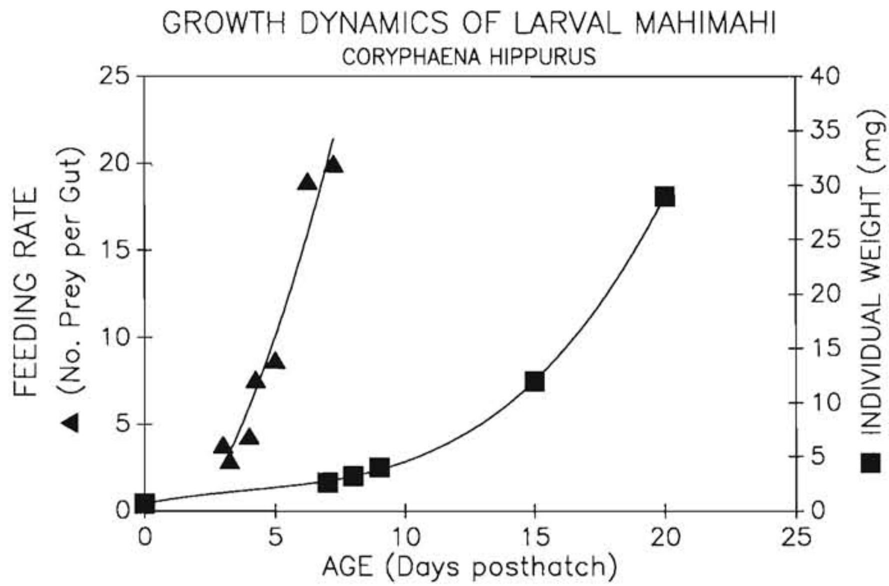


Figure 5. — Growth Dynamics of Larval Mahimahi, *Coryphaena hippurus.* Triangles track feeding rate. Squares track larval weight gain.

LARVAL REARING

Planning and Growth

The growth rate of mahimahi is phenomenal, decelerating very gradually compared to other fishes. From first feeding (0.67 mg blotted fresh weight) to 6 months (1.7 kg), average daily weight gain is 8.6 % : i.e. (1.7×10^3 g/0.6×10^{-3} g) exp 1/180 days. However, during their first three weeks, weight gain exceeds 25 % per day, and live food production has to keep pace. A 25 days old PL can weigh 60-300 mg, depending on food, temperature, and health. Mahimahi can exceed 1 gram at 30 days, 40 grams at 60 days, 300 grams at 90 days, and 2.4 kg at 6 months. Food conversion efficiency (FCE) is about 30 %, so larvae need to eat at least 83 % of their body weight (0.25/0.3 = 0.83) to gain 25 % of their weight daily. We offer 100 % daily. Satiation feeding is okay, as long as phytoplankton density in the rearing tank is greater than 5000 cells/ml. Note in Figure 5 that food consumption increases astronomically as larvae grow. Growth rate is affected by tank size, water quality, temperature and feeding.

Mahimahi go through several different hatchery phases. Larval behaviour changes as mahimahi grow from the yolksac to feeding to postlarval (fry, or PL) to juvenile (fingerling) stages. Water quality control and optimal diet change as behaviour changes. In this text, larval phases are divided according to diet type. Hatch usually occurs in the night or early morning. The daytime period following hatch is called « day 0 », i.e. less than 1 full day after hatch. Best survival is obtained by feeding rotifers on days 2-8, copepods day 6-21, brine shrimp day 10-25, mahi hatchlings day 18-40, and nonliving foods after day 30. Food consumption during days 15-20 is around eight grams of copepods and 50 g of brine shrimp nauplii (blotted fresh weight) per 1000 fish. This food can be provided with 80 litres of copepod culture and 25g of brine shrimp cysts. For 22 days old mahimahi at 30 mg each, growing 18 % per day with a 30 % FCE, you'll need to provide 30000 hatchlings per 1000 PLs per day. By day 30, you'll need 110000 hatchlings per day, and by day 45 (maximum live food consumption) you'll need 1.4 million healthy hatchlings each day, as a sole food for 1000 PLs. The development of a successful artificial diet will greatly reduce these requirements. Until such a development, we recommend weaning to chopped or blended squid (with vitamins added, or with supplemental fish, chicken, or beef liver), beginning about day 30.

Egg collection and incubation

Eggs, (1.3-1.6 mm diameter) are incubated two days (one night) in a submerged, heavily aerated, screened vessel, with 10 % seawater exchange per minute. Prior to hatch (day -1), we net up to 400000 eggs into a 200 l. static incubator, aerate heavily, and provide 4-8 Lpm of new seawater.

Feeding the Larvae

The First Week Posthatch : Two (26-27°C) to three (24-25°C) days after hatching, mahimahi larvae develop pigmented eyes and functional mouth parts, and can be netted into rearing tanks for first feeding. Best rearing tanks are cone bottom, gel coated fiberglass, with central aeration (no diffusers). The central standpipe should have 60-100 ñm nytex screen to prevent plankton loss during flushing. Add 2 % algae (at 0.5-1 million cells/ml) on day 2, and 1 % daily through day 25, if needed, to maintain 5000 to 20000 algal cells/ml. Add 1-2 rotifers per millilitre (R/ml) after stocking the larvae. Mahimahi will find 1R/100 ml. Plan on 500 R/larva, though they usually eat 100-200/day at first. Ten litres of rotifers culture, at 100 rotifers/ml (0.18 g wet weight per litre) stocked on day 2, should reproduce within the larval rearing tank and provide a continuous supply of food for 1,000 larvae through the first week.

Day 6-22, The Copepod Phase : This phase can be a time of heavy losses if larvae are not well fed prior to metamorphosis. Around 12-14 days, pelvic fins emerge, and the straight gut twists and adds several organs. Postlarvae (PLs) spend more time near the tank bottom, and have to be avoided or returned during vacuuming.

Day 18-45 Postlarvae : PLs should be fed mahimahi hatchlings as soon as they will eat them. Ours start at day 18 (about 15 mm TL at 24-25°C). Day 2 larvae weight about 0.7 mg wet; day 0 « yolk sac larvae » weight 0.8-0.9 mg each. Note the example feeding rates from the « Planning and Growth » paragraph. By day 30, or sooner, PLs should be weaned to squid paste, or a pelleted feed. Mahimahi PLs will eat flake foods and freeze dried commercial foods by day 18, but we have not yet found a food of this type that promotes good growth and survival for young PLs.

Cleaning and Disease Treatment

Sea water (SW) exchange should be gradually increased from 10 % on day 3, to 30 % per day (0.36 volumes) days 7-10, 60 % (0.9 volumes) days 11-13, 90 % (2.3 volumes) days 14-18, 98 % (4 volumes) days 18-21, and 99.9 % (7 volumes, i.e. 20 lpm in a 4000 litre tank) after day 21 (based on a stocking density of 1-2 larvae per litre). Vacuum the bottom of the rearing tank (a swimming pool vacuum attachment works well) into a screened box to see if larvae or food are on the bottom. Food and larvae can be rinsed and returned, especially after day 14, when larvae become more valuable and more tolerant of handling. Scrub the bottom and sides daily with a scrub pad on a stick (eg. « Doodlebug »).

Usually, the first signs of impending disease are reduced growth and a noticeable number (10 %) of nonfeeding larvae. Our diagnostic procedures are still in the development phase, and new pathogenic bacteria species arise fairly often. Therefore, in order to react effectively against larval pathogens, we currently recommend routine identification of bacteria species and antibiotic sensitivities prior to mortality (i.e. every day, especially days 15 through 30). We have not found any single antibiotic that is effective against all pathogenic bacteria. Disease can sometimes be avoided without drugs by keeping larvae well fed and uncrowded, by frequently vacuuming bottom debris and flushing out dissolved organics and particles that act as bacterial media, and by meticulously avoiding introduction of pathogens. Our major sources of catastrophic diseases are live plankton cultures, and poorly stored non living foods.

SUMMARY

Disease, and reliance on live plankton cultures are the factors that limit our hatchery production yield. Successful transition to nutritious non living foods signals the onset of the juvenile grow-out (or ocean release) period. The aquaculture potential of mahimahi is still being tested, but the prognosis is good enough to encourage at least 2 commercial ventures to continue development. Statements from these companies follow.

STATEMENTS FROM COMMERCIAL VENTURES

NORAQUA

A Norwegian company doing mahimahi research in Florida and the Bahamas for the past 4 years.

The following status is quoted from Randy Hagood

— Satisfactory control of spawning and larval rearing.
— Grow-out to 10kg has been done, most likely production size less than 5 kg.
— FCR now down below three with fish meal based feeds.
— Have tested net-pen grow-out in Bahamas with encouraging results (if you overlook the sharks and 13 degrees water temperatures).
— Have decided to develop a pilot scale commercial farm with on-shore grow-out tanks.
— Most likely site-Hawaii, and hope to build farm this year.

SOUTHERN SEA FARMS LTD (SSF)

An Australian company based in Perth, SSF started research and development in late 1985.

The January 1989 issue of Fish Farming International, pages 12-13 have a good description of SSF's status. SSF is a public corporation and their 1988 Annual Report has very nice pictures and a comprehensive report of activities. Steve also reports :

SSF now has 3 pilot stage grow-out trial sites along the west coast, spanning 20-30°C. They are testing sea cages and fiberglass tanks so far, and all 3 sites are doing well. The Albany site (South) is a salmon cage farm : mahimahi are resistant to a local isopod that kills salmon, and mahimahi are stronger than salmon when accidentally dropped on the rocks; mortality was 5 % the 1st week, with no further mortality to the present 2 months.

Quoting from page 1 of the SSF 1988 Annual Report :

« SSF is on the verge of commercially farming.mahimahi. »

« Significant achievements during the year are summarized as follows :

Upgrading of the hatchery facility at Yanchep and expansion of its production capacity to enable pilot study grow-out trials to commence;

The vital discovery of a link in the complex live food chain of Mahimahi larvae;

Development of new live food enrichment techniques, and their subsequent modification to suit Mahimahi larval culture;

Development of specific inert pelletized food and the technology to wean the domestic strain of Mahimahi juveniles onto hard pellets at an early age;

The continuing co-operation and joint research with Curtin University of Technology and the Queen Elizabeth II Medical Centre into the morphology and histology of early larvae;

The commencement of a worldwide search for farming sites to efficiently service major international markets.«

PROFIT POTENTIAL WORKSHEETS

Although we can now produce enough juvenile mahimahi to test tagging and aquaculture, actual grow-out trials are not documented. The following cost spreadsheets are presented as drafts, using what we know about mahimahi to date. The author is not an accountant or economist. The purpose of this presentation is to promote workshop discussion of realistic costs for aquaculture.

ANNUAL COSTS FOR A PILOT SCALE MAHIMAHI FARM

Cost Item	Annual cost Current Technology Stock 250 fry *pers 200 m^2 tank*		Annual cost Predicted Technology Stock 1000 fry *per 200 m^2 tank*	
Feed	11250	FCR = 1 :1	45000	US$1/TON
Fry	5625		22500	in-house
Misc.	10000		10000	
Electr.$0.11/kwh	40000	2000 gpm SW = 40kw	40000	
part. labor				
Staff (3)	54000		54000	
Maintenance	2000		2000	
Marketing				
TOTAL VARIABLE	122875		173500	
Management (1)	30000		30000	
Land	750	$1500/acre/yr or	750	
Depreciation	37250	(10yrs on capital	37250	
Interest				
Fees				
Insurance				
Accounting				
TOTAL FIXED	68000		68000	
TOTAL COSTS	190875		241500	
Prod. value	90000		315000	
Number of fish out	4500	1500 × 3 crops/yr	18000	
Production (lbs)	22500		90000	
Mkt. value ($/1b)	4		4	
Net profit	− 100875		73500	

CAPITAL COSTS, 1/2 acre		
Buildings		
Office/lab	35000	12ft × 36ft trailer + office supplies
Hatchery	60000	fiberglass roof, open sides, slab
Equipment		
Freezer	20000	Oahu Sales Inc, 8' × 12' 3HP, 4.4kw
Pumps	40000	4 × 15HP(500gpm) = 33kw, + 5kw aeration
Generator	25000	40kw, used (80kw = $25000)
Truck	10000	utility pickup
Hoist	5000	Fish transfer/harvest (global catalog)
Grounds		
Grading	50000	Pre-slab leveling, etc.
Plumbing	25000	(12" × 400') + (4" × 1000') + (2" × 400')
Electric	15000	trenching, installation, hardware
Concrete	40000	($1.60/sq.ft.) 420cu.yds $85/yd
Install concrete	40000	hyperlon = $25000;FRP = $480000
Shade/shelter	7500	($0.33/sq.ft.)
TOTAL	372500	

HATCHERY PRODUCTION COST

For taggable or stockable juvenile mahimahi. Draft of August 31, 1988. This does not include the cost of research. Several cost options are presented, but the most likely cost for large scale commercial hatchery production is option « D ».

CURRENT STATUS AT WAIKIKI AQUARIUM

1.	PRODUCTION = 400 fish/4,000L tank/mo	
2.	LABOUR = 1.6 PEOPLE × ($1500 + 30 % benefits)	$3120
3.	UTILITIES = 10 % OF No.2 =	312
4.	SUPPLIES (Mostly broodstock food)	268
5.	COST PER 400 FISH =	$3700
	= $9.25 EACH	

Production is limited by tanks, space, and labour.
Both staff must be skilled.
Fry Food = [20g × 1/0.3FCE × 1LB/454g × $0.76/lb] = $0.11/fish.

CURRENT POTENTIAL (Current technology, bigger facility)

1.	PRODUCTION = Same as « D », below = 60000	Juv./mo
2.	LABOR = (as per « D », below) + $1300	$7150
3.	FOOD = [60000 × $0.11] + $1300 BrdStk	7900
4.	UTILITIES AND SUPPLIES	2450
5.	DEPRECIATION ON $250000/20 YRS	2500
6.	COST PER 60,000 FISH (20g)	$20000
	= $0.33 EACH	

Production is based on staggered batches (130 000 l tank per week yielding 15 000 juveniles at the end of 2 months). Larval technician cares for 8 tanks per day. Broodstock technician cares for 10 tanks per day, with 1 male + 11 females per tank. Labour for larval rearing = 1 hour cleaning and monitoring per tank. Labour for broodstock = 10 min feeding + 15 min cleaning + 20 min egg collection and hatch treatment = 45 min/tank. To feed 60 000 PLs during the hatchling a food phase (days 20-45, 4-tank avg. wt./PL = 0.5 g) requires 0.5 g × 20 % growth/day × 1/0.3 FCE × 1000/0.9 g per 1000 hatchlings = 370 hatchlings per average PL = 22 million hatchlings per 60 000 PLs = 110 females × 400 000 eggs per spawn. Females weight about 4 Kg, males about 8 Kg. Each tank is fed 3 Kg of squid at $0.67/lb = $133/tank/mo.

Some costs might be saved if eggs were collected opportunistically from a grow-out farm.

CURRENT ENHANCEMENT POTENTIAL

Unweaned PLs, age 25 days, using current technology, genetically tagged, released into food-rich, non-predatory environment*.

1.	PRODUCTION = 15000 fish/30000 l tank/mo × 8 tanks per person/day = 120000 fish/mo.	
2.	LABOR = Same as « D », below=	\$5850
3.	FOOD per 120000 PLs :	660
4.	UTILITIES and SUPPLIES	1090
5.	DEPRECIATION on \$200000/20 years	2000
6.	COST PER 120,000 FISH 0.1g	\$9600
		= \$0.08 EACH

Food cost = \$5.50/1000 PLs=(0.16gBS cysts/0.1gPL)
Hatchlings not needed as food. *FR/NP environment may not exist; no tests to date.

POTENTIAL COST, USING COMMERCIAL FOOD (If it were available)

1.	PRODUCTION = 15000 FISH/30,000 L tank × 8 = 120000 per 2 months, = 60000 Juveniles/month.	
2.	LABOR = [\$2500 + 1000 + 1000] × 1.3	\$5850/Mo
3.	FOOD = [60000 × \$0.10] + \$150 BrSt	6150/Mo
4.	UTILITIES and SUPPLIES	1000/Mo
5.	DEPRECIATION on \$200000/20 YRS	2000/Mo
6.	COST PER 60000 FISH, 20 g	\$15000
	\$0.25 EACH	(Taggable juvenile)
7.	COST PER 1g FISH, Age 30 days = \$7450/120000 =	
	\$0.06 EACH	(Stockable PL)

Production limit based on :

1 hour cleaning & monitoring per 30,000 L tank = 8 tanks per day per person (for 0-30 days larvae/PLs); maintaining 1 broodstock tank (1M + 2-3 F) + 1 brood grow-out tank; 1 full day food preparation, culture work, broodstock, administration = 2 people per day.Staff = 1 manager + 2 technicians (minimum) to cover 7 days workweek. PL food cost based on price of squid (\$0.76/lb). Commercially available hatchery feeds now cost \$36-58/lb, and they do not work for mahimahi.

POTENTIAL BENEFIT/RETURN

1. 6mo old mahi=5lb × \$3.00/lb = \$15 each fish
2. 1yr old mahi=20lb × 3.50/lb = \$70 each fish
3. 4mo old mahi=1lb × 2.50/lb = \$2.50 each fish

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