Mariculture of Dolphin (*Coryphaena hippurus*): Is It Feasible?

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ABSTRACT

A fast natural growth rate and spontaneous captive spawnings recorded in Japan and Hawaii suggest the dolphinfish (*Coryphaena hippurus* Linnaeus) as a potential species for mariculture. On the other hand, their adaptation to a pristine environment, with no confining solid surfaces, suggests potential difficulties in husbandry of this oceanic fish. Since 1981 a program at the University of Miami's Rosenstiel School of Marine and Atmospheric Sciences (RSMAS) has examined further the feasibility of dolphin culture. The three-phase approach included (1) a survey of the scientific literature of dolphin and current status of the dolphin culture concept, (2) an attempt to collect and rear planktonic eggs from the Florida Current and (3) the capture and transport of wild dolphin from the Florida Current and their maintenance in systems using water from Bear Cut, Florida. Relevant dolphin literature is identified and the history of dolphinfish rearing and captive spawning is summarized. A survey of ichthyoplankton for dolphinfish eggs was initiated early in the project, but discontinued in order to attend to more promising areas of the project. Sub-adult fish captured by conventional fishing methods (rod and reel) were captured and transported to an outdoor circular tank at the RSMAS campus. Sources of mortality of these fish and their captive-spawned progeny are reported and discussed.

This presentation deals with the dolphin fish (*Coryphaena hippurus*) and its feasibility for mariculture. From a mariculture standpoint, the single most attractive feature of this lovely food, game and sport fish is its fast natural growth rate. On the other hand, its adaptation to a pristine environment, with no confining solid surfaces, suggests potential difficulties in husbandry of this oceanic fish species.

Since 1981, a program at the University of Miami's Rosenstiel School of Marine and Atmospheric Sciences (sponsored by the Wallace Groves Aquaculture Foundation) has examined the feasibility of dolphin mariculture. The three-phase approach included: first, a survey of the scientific literature of dolphin and current status of the dolphin culture concept; second, an attempt to collect and rear planktonic eggs from the Florida Current, and, third, the capture and transport of wild dophin from the Florida Current and their maintenance in systems using water from Bear Cut, Florida.

The first phase, the literature search and survey, yielded an extensive, scattered literature. Palko, et al. (1982) published a synopsis of biological data on *Coryphaena*. This is currently the best single starting point for those interested in this genus. Here, briefly, is the history of dolphin rearing before the outset of this project: Hassler and Rainville (1975) were the first to report the rearing of dolphin from wild-caught eggs to a maximum age of 85 days. In 1978, Soichi described the spawning of several captive dolphin in an oceanarium setting in Japan. His attempts to raise the larvae were unsuccessful. Hagood and Rothwell's 1979 Sea Grant reports presented for the first time both the captive spawning and the successful rearing of dolphin.

In the second phase of our research at Miami, we made a series of surface plankton tows with 1-m nets in the Florida Current, twice monthly, at the western edge of the Gulfstream and also 5 to 7 miles offshore. The plankton was transported with aeration to the laboratory and the eggs sorted with a bulb pipette. The bimonthly tows yielded on average only about 0.3 eggs per net towing hour during the winter months, about 3 eggs per net towing hour in April, and nearly 30 eggs per net towing hour in May and June. This phase was discontinued in order to attend to more promising areas of the project; however, the eggs collected became the subjects of our first observations and rearing attempts. The larvae from these eggs were fed wild-caught zooplankton. From this work, we developed a food-size regimen which has also provided a guideline for feeding cultured food organisms.

The third phase of the project dealt with the capture, handling, transport and maintenance of dolphin caught by conventional fishing methods, (hook and line). A circular, outdoor pool was constructed and later enlarged by connection to a smaller pool. Sheets of half-inch plywood were overlapped and bolted together to form a circle 26 feet in diameter. A flexible vinyl liner contains the water, and is cut and gasketed for the central double-standpipe drain. Extra standpipe height provides support for the fish-net cover which effectively restrains these high-jumping fish. Sand and cartridge filters reduce the load of suspended silt and biogenous material. Flow rate is about 380 *l*/min.

We have held three different sets of fish as potential broodstock in this open system; two of them wild-caught and one our own captive-spawned and reared dolphin. Their diet in this system was cut fish, supplemented with squid and vitamins. Mortalities among broodstock fish resulted from protozoan parasites (*Trichodina*), dinoflagellate parasites, (one like *Amyloodinium*), physical trauma, agonistic behavior and unknown causes. All three groups grew well and spawned viable eggs. All fish participated in spawnings except those sustaining profound injuries (such as blindness) related to capture. Temperatures in the broodstock pool have ranged from 19.0 to 33.0°C; salinities from 25 to 37ppt. This F_1 generation reached sexual maturity and first spawned 6.5 months after hatching, at an estimated average weight of approximately 2.5 kg.

Two groups of F_2 generation fish were reared from their spawns. One group of 125 juveniles (ca. 4-5 cm TL) was shipped to the Bahamas for the Wallace Groves Aquaculture Foundation; another group of 40 juveniles (ca. 10 cm TL) was taken from our tanks by some predator, vandal or miscreant. At about this same time, our broodstock slowly perished from known and unknown causes previously mentioned.

We were forced to collect wild broodstock again in fall of 1982. Our collection of fish on hook and line yielded four healthy dolphin, after losing a few fish from collection-related trauma. These grew well in the broodstock system, from an estimated weight of less than 0.7 kg to about 5 kg in 30 days. Their growth rate is no less remarkable for having occurred while they produced 2-20 thousand infertile eggs daily which we collected, as well as an undetermined number flushed out of the drains of our open system. These fish, all four of them female, spawned first after 21 days in captivity and almost daily thereafter. Not until 27 September 1982 did we succeed in capturing any males for this broodstock. An immature male (about 0.5 kg) grew well after a 10-day period of shock from handling, and has been spawning, so we have fertilized eggs. Three new cohorts of larvae are now being raised in the lab.

Sources of mortality among our larval and juvenile dolphin have been bacterial disease, protozoan parasites, cannibalism and unknown causes. Highly magnified views of a sagittal section of a dolphin larva show large bacterial colonies in the developing fins and gills.

We have successfully reared larvae in both open systems and semi-static aquaria with the "green water" technique, as shown previously in 70-*l* aquaria. Fiberglass tubs (380 *l*) have also been successful as egg incubators and larval and juvenile rearing tanks. We have raised fish as large as 23 cm in these tubs, but recommend transfer to larger systems at sizes about 3 to 5 cm.

I want to offer a summary statement concerning what has been covered so far, because, up to this point, I have been reporting from actual experience and results. Dolphin culture has been shown to be biologically and technically feasible. The unsolved technical problems are, in my estimation, solvable.

Now I will address some of the factors related to economical feasibility of dolphin mariculture. Just over a decade ago, at a World Mariculture Society Meeting, a session on Aquabusiness and Management was held in which the moderator's (Webber, 1973) opening comments included this statement: "If aquaculture, as a scientific concept for food generation, is to mature into a significant wealth-creating endeavor, then the production technologies which we have been developing must be integrated into the larger system of business management that includes fiscal controls, intensive physical and biological management of the environment in order to produce the products in commercial quantities; processing and food technology which must be

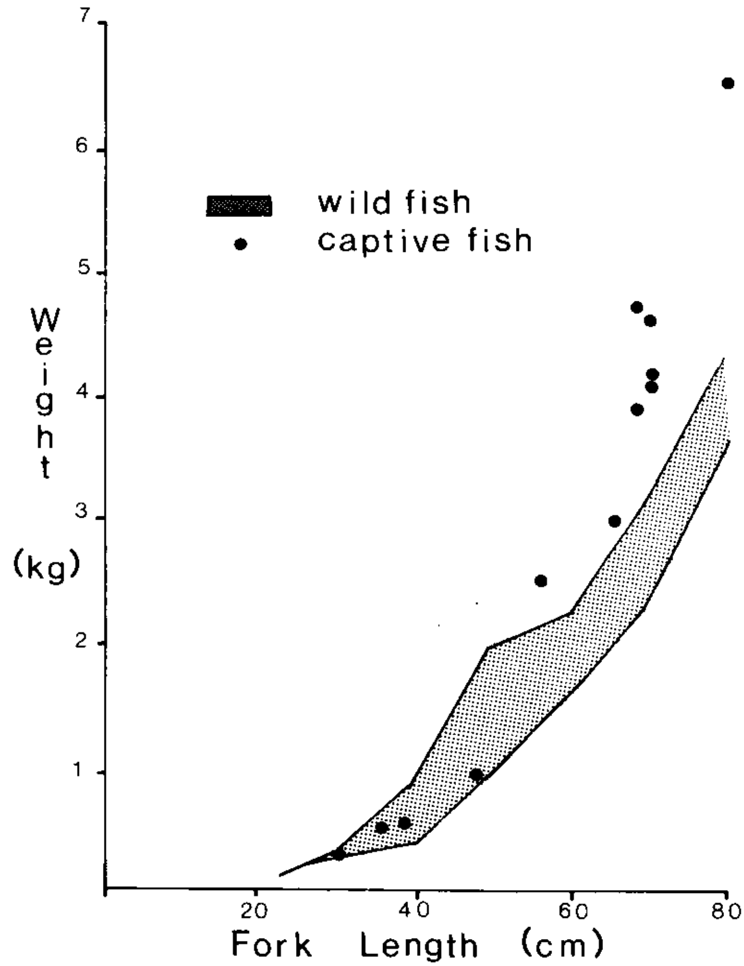

Figure 1. Fork length vs. weight of wild and captive dolphin *Coryphaena hippurus*. Shaded area depicts range of values reported for fish in the Atlantic, Pacific and Indian Oceans. Circles represent measured values for individual F_2 generation fish.

coordinated with sales and marketing, to include packaging, distribution and product development in response to consumer demands, etc." This statement is still useful today, as it points to the areas with which technical and biological fish culture must be economically integrated. Dolphin culture, in particular, must address all of these aspects of business management if it is ever to succeed financially.

In my opinion, the single greatest hurdle for the hopeful dolphin farmer to overcome will be food costs. On our research project, we pay about U.S. $0.50/lb for high quality food fish. After loss of inedible and uneaten portions, spoilage, and other forms of waste or loss, the food cost nearly U.S. $1.00. Hassler and Hogarth (1977), gave an average food conversion ratio for dolphin as 3.44. Using, conservatively, 4:1 as a conversion ratio, a 4-lb fish will have consumed about 16 lb of food, costing us about U.S. $16.00. There are occasionally times and places, (such as in Hawaii), where a 4-lb dolphin can be marketed for more than $16.00. But, this is generally far from feasible. For marketing in most of the world, let us assume that: (1) The food cost must be reduced substantially before profit can be realized. (2) Specialized marketing techniques are called for to secure a price above that which is merely competitive with the fishery. Regarding the marketing of farmed dolphin as a deluxe product, a comparison of length-weight relationships is of special interest. Figure 1 gives the fork length versus weight for wild and captive *Coryphaena hippurus*. The cross-hatched area represented the range of values reported for dolphin in the Atlantic, Pacific and Indian Oceans (Bannister, 1976; Beardley, 1967; Kojima, 1966; Morrow, 1954; Rose and Hassler, 1968; and Schuck, 1951). The circles represents lengths and weights of our F_2 fish. All the latter lived their entire lives in captivity. Note the abnormally high weights (and these represent abnormally high filet weights) in cultured fish over 50 cm fork length. This simple analysis provides a biological evaluation of the rearing system and also a management tool by suggesting optimal time to harvest. It also shows that a cultured dolphin at any length over 50 cm is worth more than a wild-caught dolphin of the same length.

Food cost reduction can be approached in the following ways, each of which has its particular limitations: (1) Bulk purchase of the same food would reduce the cost from our present level; (2) The by-products or by-catch of a seafood industry could be incorporated in the ration; (3) The by-products of a non-seafood industry might supply animal protein (Example: Beef tankage or by-product); (4) Animal food might be cultured (e.g.: *Tilapia*, Poecilliidae); (5) Vegetable protein and energy sources might be incorporated into the diet. (e.g.: soy, rapeseed); (6) Microbial technology might eventually provide essential protein, energy, and vitamin components (Peppler and Perlman, 1979).

I have chosen the reduction in food costs as an area to explore because I consider it most important. Serious consideration and testing of *energy costs* and *stock density* will also be necessary. Energy costs, (especially the cost of pumping water), and stock density limitations will interact, and they will be different for each conceivable type of grow-out system, (e.g., cage, raceway, pond).

SUMMARY AND CONCLUSIONS

Dolphin can be propagated from conditioned wild-caught subadults or from domestically-raised broodstock. The consistency of this process would not limit mariculture.

Larvae can be raised both in open and in closed systems. While not yet at the cookbook stage, hatching success and larval survival suggest this area, too, would not limit mariculture.

Grow-out systems on a mariculture scale and stock density have not been tested, nor have adequate alternative foods been developed.

With a growth rate in captivity, which is perhaps the fastest in the world, dolphin continue to attract attention as a candidate for mariculture.

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