References

CIBA Revue 1974: Sporenelementen vandaag.

DUDOK VAN HEEL, Dr. W. H., 1972. Raised levels of mercury and chlorinated hydrocarbons in newly captured *Tursiops truncatus*, Mont. from Florida waters. J. Aq. Ma. 1 (2): pp. 24-36.

POELMA, F. G. DVM, G. A. DE VRIES, E. A. R. BLYTHE—RUSSELL and M. H. F. LUYKX, 1974. Lobomycosis in an Atlantic bottle-nosed dolphin in the Dolfinarium Harderwijk. J. Aq. Ma. 2 (3): pp. 11-15.

— — —

AN OVERWIEW OF WORLD WIDE CULTURED FISH PRODUCTION

by E. Evan Brown, Professor of Agricultural Economics at the University of Georgia, Athens, Georgia, U.S.A.

Summary

Fish farming in salt water is usually referred to as mariculture; fish farming in fresh or brackish water is known as aquaculture. This paper presents basic information on both types of fish farming, specifically, (1) total world fish supplies including mariculture and aquaculture and, (2) mariculture and aquaculture in selected countries, i.e. — Japan and the United States. The presentation pertains mostly to finfish. The interest in production of finfish through mariculture and aquaculture is at a high level. In certain countries such as Japan production is increasing rapidly. In the United States we have not yet achieved a breakthrough in mariculture. In aquaculture the past five years has seen rapidly increased production of rainbow trout and channel catfish, a trend which will probably continue.

Some basic information

More than 70 precent of the solar energy reaching the earth falls on the surface of the oceans. Sea water is a dilute broth, holding in solution all the chemical nutrients necessary for the growth of plants. The bounties of the sea might seem endless as shown by great schools of herring in the north Atlantic, endless numbers of tuna in the central Pacific, and hordes of salmon surging up Alaskan spawning streams. Yet in the face of these theories and observations the sea produces only two to three percent of mankind's calories. Like so many of the land's riches, the plant nutrients of the sea are very unevenly distributed. The range of productivity in the sea is at least as wide as the range on land. Fish farming may be compared to intensive agriculture practices such as greenhouses,

coastal areas to forest, and moist grasslands and land under ordinary cultivation. But some parts of the ocean support no more plants and animals than deserts. These differences are largely due to chemical nutrients in solution plus light which stimulates production of microscopic plants.

producing fish by farming, whether it be mariculture or aquaculture.
than the cost on land. On a world-wide basis it costs half as much to gather a ton of protein from fish as from beef. In the United States marine fish usually has sold for about one-third the price of competitive meat protein. There are also significant differences between the costs of gathering fish and the costs of producing fish by farming, whether it be mariculture or aquaculture.

Many people believe that fish farming is the answer to obtaining vast quantities of inexpensive food. This is not true. Fish farming should be looked upon only as a supplementary source of food since retail prices of farmed fish will be from two to five times higher than the retail prices of fish gathered by net or traps. The world catch of fisheries products from our oceans and natural waters in 1972 was 65.6 million metric tons and appears to be stagnated between 65-70 million metric tons.

For some countries, fish is a major source of animal protein. More than half of the human population depends on fish for a large part of their animal protein requirements. In Japan for instance 55% of the animal proteins come from fish. In the 50 countries which contain the bulk of the world's population, 10% or more of the animal protein consists of fish (FAO, 1966).

With this brief introduction, an attempt will be made to present what is happening in fish farming in two countries. These are (1) Japan, which is a world leader in fish farming activities and volume and (2) the United States, in which fish farming is relatively new. First mariculture in both Japan and the United States will be covered and secondly, aquaculture will be presented separately for Japan and the United States.

Mariculture

In Japan in 1950 the total harvest of marine species form fish farming was only 53,000 tons. By 1960 the harvest was up to 313,000 tons and by 1972 to 648,000 tons (Min. Agric. Forest., Japan, 1967) or a 1,123% increase in 22 years. This may appear to be a large volume but it amounted to less than 6% of total seafood sold in Japan. The value of the cultured marine species was two times higher per lb. than the wild marine fish.

Cultured marine finfish include yellowtail, mullet, shrimp and puffer. Shellfish cultured include oysters, clams, and scallops.

In the past marine finfish were cultured in ponds and tides were used in water exchange of fish ponds. By opening sluice gates during flood tides, sea water was drawn in and then the gates were closed to prevent drainage during ebb tides. With the recent development of bacterially resistant chemical fibers, culturists use

pens that float in the water. They permit good water exchange and pen costs are relatively low. Inexpensive marine fish are used to feed cultured yellowtail, puffers, and shrimp. In essence natural foods are supplemented. This raises the cost of production for cultured fish. Food conversions vary depending on water temperature, kind of food, size of the fish, and other factors. This is also true for cultured fresh water species. For yellowtail this is in the nature of 8-11b. (HATANAKA, 1958) food fish fed per 1b. of gain of the cultured fish. Even with low food fish prices this means a relatively high cost of feeding the cultured fish.

Shrimp are bred in captivity and thus there is no natural limit on reproduction. Yellowtail culture is flourishing, but the seedling fish supply, coming as it does from natural sources, is insufficient to meet the demand.

As mentioned earlier, cultured marine fish are relatively expensive as compared to wild harvested fish. Therefore, it is evident that the cultured species border on the frontier of gourmet items. One of the most interesting of these is puffer. The Japanese have a saying, „to savor fugu (puffer) is to risk one's life." The ovaries, liver, skin, and intestines of the puffer are extremely poisonous. About 100 Japanese die each year from eating puffer. In spite of this, some 6,800 tons are consumed annually. Only a small part of the total yield is cultured.

In the United States here is some existing mariculture with shellfish, primarily oysters. Some clams and scallops are also cultured. We have had only one commercial venture for producing shrimp. This venture is located near Panama City, Florida, where an estuary has been enclosed by nets.

Various state and federal agencies are working with finfish in mariculture. To date, (1974), there are no successful commercial activities in the U.S. Several promising attempts are underway with salmon in Oregon and Washington. These results are due to several factors but in general the cost of production at present exceeds market value. In spite of the lack of singular success, marine mariculture of finfish is assumed to have extra-ordinary long-range potential.

TABLE 1. Production achieved with present methods of fish culture (GAUCHER, 1968).

Types of fish culture	Production per acre per year (1b)
Fresh water ponds	
Unfertilized	50— 1,000
Fertilized	150— 1,500
Fertilized and prepared feed added	2,200— 5,000
Brackish water ponds	400— 2,000
Flowing water	
Trout	10,000—70,000
Carp or catfish	to 1,000,000

Aquaculture

The total fresh and brackish water fish production of the world is around 7

million metric tons (FAO, 1965). Only vague guesses are possible of the percentage of this tonnage that is cultured. Mainland China alone reports a pond fish production of 1.5 million tons. The rest of the world may produce another 1.5 million tons for a total of 3 million tons of cultured finfish. By the year 2000 it is estimated that this cultured production may reach 30 million metric tons (BRADACH, 1968).

High production is possible on limited water areas. Table 1 shows some examples of production now being achieved.

Aquaculture in Japan

In 1973, 72,600 short tons of freshwater cultured fish were produced in Japan. This volume represented only 1.0% of Japan's total fish catch. However, because of the unique nature of the demand for cultured fish the value of the product was 2.3% of total wholesale sales. This means that each 1b. of cultured freshwater fish was valued at more than 2.3 times the average value of other fish. The total volume of fish harvested by the Japanese places that country in a position second only to Peru. However, in value of catch, Japan ranks first, since most of its catch goes for higher priced human food rather than for processed fish meal as is the case in Peru. Four major species of fresh water fish are produced in Japan by culturing methods: rainbow trout *(salmo irideus);* ayu or sweetfish *plecoglossus altivelis)* which are not native to the United States; eel *(anguilla Japonica);* and carp *(cyprinus carpio).* Japan has native catfish but regards them as a nonedible trash fish. In 1973, the following percentages of fish produced were cultured: 100% of the trout; 86% of the eel; 83% of the carp; and 28% of the ayu. The remaining volume of freshwater fish were harvested as wild fish caught in inland fresh waters, although many were produced in hatcheries before being released in native waters. Hence, to some extent these fish have been produced by artificial means even if they have not been fed to a finished weight. In recent years the proportion of fresh water fish produced under cultured conditions has been increasing. Not only has the proportion been increasing but the absolute volume has increased also. For example, 8,934 tons of eel were cultured in 1961; 16,500 tons in 1973. Similar results are shown for carp, trout, and ayu. In 1961, a total of 19,874 tons of fish were cultured. Estimates for 1973 indicate a further increase to 72,600 tons, for a total increase of 265% in 14 years.

Four different methods of culture are used in producing fresh water fish in Japan, namely, pond, running water, circulatingfilter system, and net culture in lakes. The major difference between the first three of these is the volume of available water suitable for fish production. For years the Japanese have been successful in artificially reproducing trout and carp. In 1970—71 they had a breakthrough in reproducing ayu or sweetfish. In 1974 they were able to successfully hatch eel eggs but do not know how to raise the elver during the first year of life. Hence the market supply of cultured eel depends entirely on the catch of the larval (glass) eel (one year old).

Some price comparisons illustrate the relative value of these cultured species in the Japanese market. In 1973, the Tokyo wholesale price for eel was $2.71 per lb.; ayu, $ 159; carp, 70 cents; and rainbow trout, 61 cents. It should be pointed out that after 70 years of culturing the Japanese have not embraced trout; about 95% of their total production is exported to the U.S., Australia and Europe.

Aquaculture in the U.S.

In the United States there are essentially only two fresh water species cultured: (1) trout, essentially rainbow *(salmo irideus)* and (2) catfish, essentially channel catfish *(ictalurus punctatus)*.

Trout in the U.S., in general, are produced in the Rocky and Appalachian mountain chains. Optimum water temperatures for good feeding and rapid growth is between 65—68°F. These temperature requirements restrict the areas of production. In general, running culture is practiced in either concrete or earth raceways or earthen ponds. The major production area is the Snake River Valley in Idaho.

Trout farmers selling for the food market receive in the neighborhood of 62—63 cents per lb. liveweight. The dress-out is about 82%. The wholesale price is about $ 1.25 dressed and the retail price about $ 2.15 for dressed fish (CLONTZ). Trout have been cultured in the U.S. for at least the past 75 years. However, the growth of the industry has quickened in recent years. Discounting live trout sold per public and private stocking it has been estimated that approximately 20.5 million lb. (10,250 short tons) of processed (dressed weigth) trout were sold for food use in 1973. Of that amount, about 18.9 million lb. (CLONTZ) were produced domestically and 1.6 million lb. (ORAVETZ) imported. These figures are for farm-raised rainbouw trout and do not take into consideration lake trout and other fishery items sold as „trout".

Channel catfish is the other species of fish cultured in the United States. Culture of catfish began about 1961 in the Delta area of Mississippi and Arkansas. Until about 1968 the industry was based almost entirely on the market for live fish stocking farm ponds, other fish farming operations, pay lakes, and reservoirs. This market continues to be important and its continued growth seems likely. More recently, however, the emphasis has ben directed toward the problems of developing broader markets for finished catfish products. Catfish are produced in one of three ways: ponds, raceways, and cages. In 1970 there were approximately 1,600 commercial catfish producers in the United States (Econ. Devel. Adm., 1972). About 1,400 producers, perhaps 150 use raceways and 50 utilize cages. Raceway- and cage-produced catfish require different feed formulations than pond-cultured catfish. Their feed cost per lb. may be doubled. Complete feeds such as is fed to trout are necessary. With more intensive culture the frequence and severity of diseases and parasites increases. However it is easier to mechanize the feeding, grading and harvesting operations. Approximately 60% of the pond area is located in the Delta area of Mississippi and Arkansas. The remainder are largely scattered throughout the other Southeastern states. Most of the raceway systems were located in Georgia.

The production of raceway and cage producers would increase the equivalent acreage by some 4,000 to 6,000 acres. In 1970 approximately 34 million lb. (17,000 short tons of liveweight) of foodsize catfish were harvested and sold. Approximately 2.2 million lb. on a liveweight basis (18%) were processed for food use. The remaining 82% was sold to fee fish out operators and other live markets. While cultured catfish for food use was about 6 million lb., wild catfish sales were approximately 42 million lb. and imports were almost 9 million lb. (liveweight basis). Thus, total food sales were about 57 million lb. liveweight or more than 31 million lb. (15,500 short tons) dressed weight (the dress-out percentage of catfish is about 55% of liveweight). In 1974 the volume of cultured fish processed nearly doubled to about 20 million lb., wild fish production was about 46 million lb. and imports totaled about 12.7 million lb. Thus, in 1974 total food sales of catfish was about 78.7 million lb. liveweight or 43.3 million lb. dressed (21,650 short tons). Farm prices in 1974 ranged between 40 and 50 cents per lb. of liveweight, and retail from $1.49 to $1.69 per lb. It should be evident that catfish, like rainbow trout, is not a cheap food at present but are comparable with meats produced from land animals. This is true in spite of production per surface acre of water being many times higher than for some other meat animals such as beef and in spite of a fish feed conversion that is vastly superior to that of beef, superior to that of hogs and slightly better thant that of broilers (Table 2). These reasons may account for the renewed worldwide interest in fish culture. Offsetting the high production rate per acre and superior feed conversion is the higher cost of feed for fish and in some cases less production per man equivalent of labor.

TABLE 2. Comparison of feed conversions bij different types of domesticated animals and Cultured Fish.

Animal	Dress-out percentage	Feed Conversion	
		Liveweigth basis	Dressed weight basis
Beef	59.5	7.5 -1	12.61-1
Hogs	77.0	3.25-1	4.22-1
Broilers	74.0	2.25-1	3.04-1
Fish			
Catfish	55.0	1.5 -1	2.73-1
Rainbow Trout	82.0	1.5 -1	1.83-1

References

BRADACH, J. E. et al., 1968. The status and potential of aquaculture, particular fish culture. American Institute of Biological Sciences. Washington, D. C. p. 22.

BROWN, E. Evan, 1969. The fresh water cultured fish industry of Japan. University of Georgia, College of Agriculture Experiment Station. Athens, Georgia. Research Report 41, and personal correspondence in 1974.

CLONTZ, G. W.. Personal correspondence. University of Idaho. Moscow, Idaho.
ECONOMIC DEVELOPMENT ADMINISTRATION, 1972. A statistical reporting system for the catfish farming industry, methodology and 1970 results. U.S. Department of Commerce. Washington, D.C. p. 4.
FAO, 1965. Agricultural projections for 1975 and 1985 (data compiled in 1960-62). United Nations, New York.
FAO, 1966. Fisheries statistics yearbook, 1955. United Nations, New York.
GAUCHER, T. A., 1968. Thermal enrichment and marine aquaculture. In ed. McNEAL, W. J., Oregon State University of Marine Science Center. Corvallis, Oregon. p. 145.
HATANAKA, M., 1958. *Tohuku Journal of Agricultural Research. 9 : 69.*
MINISTERY of Agriculture and Forestry, Japan, 1967. Yearbook of fishery statistics, 1950-1966. Department of Statistics, Fisheries Statistics Section. Tokyo, and personal correspondence.
ORAVETZ, Charles. National Marine Fisheries Service, St. Petersburg, Florida, personal correspondence.

— — —

ESTROGEN, CORTICOSTEROID AND PROGESTAGEN PATTERNS IN THE PREGNANT AND NONPREGNANT BOTTLE-NOSED DOLPHIN *Tursiops truncatus*, FOLLOWING THE INTRAMUSCULAR AND INTRAVASCULAR ADMINISTRATION OF NIH-FSH-OVINE-S9

by M. Richkind, MSc, DVM, FRVCE and S. H. Ridgway, DVM, PhD**.*

Summary

The increasing popularity of the bottle-nosed dolphin *(Tursiops truncatus)* in marinelands, coupled with restrictions upon their capture as set forth in the

* Division of Nuclear Medicine, Department of Radiological Sciences, Center for the Health Sciences, University of California, Los Angeles, California, U.S.A.
** Naval Undersea Research and Development Center, San Diego, California, U.S.A.