GEOTHERMAL AQUACULTURE DEVELOPMENT

Paul J. Lienau
Geo-Heat Center

INTRODUCTION

Aquaculture involves the raising of freshwater or marine organisms in a controlled enviroment to enhance production rates. The principal species that are typically raised in geothermal waters are catfish, tilapia, bass, trout, sturgeon, giant fresh water prawns, and tropical fish. The application temperature in fish farming depends on the species involved. Typically, catfish grow in 4 to 6 months at 64 to 75°F, trout in 4 to 6 months at 55 to 64°F and prawns in 6 to 9 months at 80 to 86°F. The benefit of a controlled rearing temperature in aquaculture operations can increase growth rates by 50 to 100% and thus increase the number of harvest per year. Water quality and disease control are very important in fish farming.

In the U.S., aquaculture projects using geothermal water occur in seven western states. Aquaculture is one of the high potential development areas for low-temperature geothermal resources. Recently, three areas in Arizona began raising catfish, tilapia and bass using geothermal waters ranging from 80 to 105°F. At the Western Regional Aquaculture Exposition held in March 1991, geothermal resources were mentioned as having tremendous potential for the aquaculture industry.

This article summarizes the development of geothermal resources for aquaculture uses which mainly began about the 1970's. Based on a survey conducted by the Geo-Heat Center in 1988 (Lienau, 1988) and updated in 1990 (Lund, 1990), there are 18 aquaculture operations using geothermal waters. The location of these businesses are identified in Table 1.

Table 1. Aquaculture Operations Using Geothermal

State	Operator	Type Fish	Res. Temp. (F°)	Max. Flow (gpm)	Annual Energy (x 10^9 Btu/yr)
AZ	Hyder Valley	Catfish, Tilapia, Bass	105	4,000	140.2
AZ	Hyder Ranch	Prawns	95	1,000	24.5
AZ	Safford	Catfish	105	1,000	35.0
AZ	Marana	Bass	80	800	28.0
CA	Hot Creek Hatchery	Trout	61	18,850	201.7
CA	Pacific Aqua Farms	Tilapia, Catfish	142	1,700	170.0
CA	Aqua Farms International	Tilapia	92	1,500	47.3
CA	Arrowhead Fisheries	Sturgeon	74	1,570	38.5
CO	Sand Dunes Hot Springs	Catfish	118	500	81.2
CO	Roaring Judy Fish Hatchery	Trout	65	1,100	62.6
ID	Fish Breeders	Catfish, Tilapia	90	7,000	174.5
ID	Lunty Fish	Tropical	90	400	14.0
NV	Hobo Hot Springs	Tropical	106	100	14.4
NV	Jackpot	Catfish, Tilapia, Sturgeon			
NV	Duckwater	Catfish	92	6,000	
NV	Wabuska	Tropical	270	1,300	
SD	Keeton Fisheries	Catfish	154		
WY	Jackson National Fish Hatchery	Trout	78	100	16.6

DEVELOPMENTS

Brief discriptions are given of the leading aquaculture operations.

Arizona

In Arizona there are 26 facilities using geothermal waters for aquaculture, primarily located in three areas: Hyder Valley (Yuma County, east of Yuma), Marana (Pima County near Tucson), and Safford (Graham County northeast of Tuscon). All of these warm water facilities use artesian or pumped geothermal well water at 85 to 105°F. In the Hyder Valley six aquaculture facilities use 400 to 850 gpm each of 80 to 105°F geothermal water. Species grown are tilapia, catfish and large mouth bass. The largest of these facilities is operated by Global Fisheries. This facility has eight ponds with 2800 ft^2 surface area each, 40 one acre ponds and one 2.5 acre pond presently in use. Hyder Ranch is rearing fresh water prawns in eight one-acre ponds. There are 800 to 1000 gpm of 95°F water pumped to the ponds and the blowdown is used to irrigate citrus.

In Marana an integrated farm is rearing largemouth bass in raceways, tanks and ponds. Fingerlings are imported and the fish are reared to one to three pounds and delivered to restaurants in Tucson and California.

Near Safford, Brown's Fish Farm conducts the largest baitfish operation in the state. Brown's also supplies bass and catfish for private stocking as well as catfish to the Urban Fishing Program. There are a couple of smaller catfish farms in the Safford area using the geothermal water common in the region (Fitzsimmons,1988).

California

In California there are six known aquaculture operations using geothermal waters out of a total of 337 licensed facilities in the state. The largest is the Hot Creek Hatchery near Mammoth which uses water from springs at temperatures higher than local stream and most groundwater in the area. Water from four springs ranging in temperature from 52 to 61°F are used for egg hatching and accelerated fish growth. The water is fed directly and mixed into raceways and hatcheries to maintain optimum growing temperatures.

At Pacific Aqua Farms near Niland, water from a geothermal well is utilized to maintain temperature for growing tilapia in ponds at 85°F. This facility has been in operation for 9 years and the only problem is cooling in the summer.

Aqua Farms International near Meca uses five wells, 100 to 350 ft deep, at 92°F for 51 acres of ponds. Originally giant prawns were grown, but now several varieties of fish are grown.

Arrowhead Fisheries started raising sturgeon in 1986 near Susanville. They currently have 12 earthen raceways about 10 ft x 50 ft x 3 ft depth and 12 FRP tanks 8 ft x 20 ft x 2 ft depth using a 74°F resource at 1570 gpm.

Idaho

Fish Breeders of Idaho, Inc. has been raising channel catfish in high-density concrete raceways for over ten years. The water comes from artesian geothermal wells, 7000 gpm at 90°F, supplying 72 raceways, each section is 24 ft long, 10 ft wide and 4 ft deep. The sections are arranged four in a series with a 2 foot drop between each section to allow for replacment of oxygen. Cold water from springs and streams is used to cool the hot water between 80 to 85°F, the ideal production temperature. Normal stocking densities are from 5 to 10 pounds of fish per cubic foot of space or 10,000 to 15,000 pounds per second foot of water. Yearly production will usually be three to four times the carrying capacity. The lower end of the farm is used for tilapia production.

Nevada

In Nevada there are three geothermal aquaculture facilities. At Hobo Hot Springs tropical viviparous fishes (platies, swordtails and mollies) are raised in high-intensity enclosed geothermal thermo-regulated and oxygenated raceways. The aquaculture facility is located in Douglas County, on Washoe Indian lands. The thermal spring flows at 100 gpm and maintains a constant temperature of 113°F. The thermal fluid contain 396 ppm TDS and is similar to other sodium sulfate-chloride springs in the region. The fluid pH is 8.9 and the water contains slightly elevated concentrations of fluoride and boron. "Livebearers" swordtails, platies and mollies, were slelected because of their suitability for culture in high pH water at the Hobo Hot Springs site.

South Dakota

Keeton Fisheries installed (Spring 1990) a recirculating aquaculture facility to raise tilapia and hybred striped bass. It is estimated the live weight will be about a million lb/year. Resource is the Phillip water supply (geothermal at 154°F) well.

Wyoming

At the Jackson National Fish Hatchery a 78°F well pumping 100 gpm is used in a ground water heat pump to heat the hatchery building (10,000 ft^2), 400,000 Btu/hr. The water then is mixed with 46°F water to heat flow thru rearing ponds.

GROWTH AND POTENTIAL

Aquaculture is one of the fastest growing industries. Catfish processing increased 21% last year. The Washington Aquafarm Newsletter reported that U.S. farmed aquaculture production has increased slightly over 20% each year since 1981. Only a very small part of that is geothermal; although, it is well known that growth rate and food conversion are greatly enhanced with geothermal aquaculture where water temperatures can be maintained relatively constant.

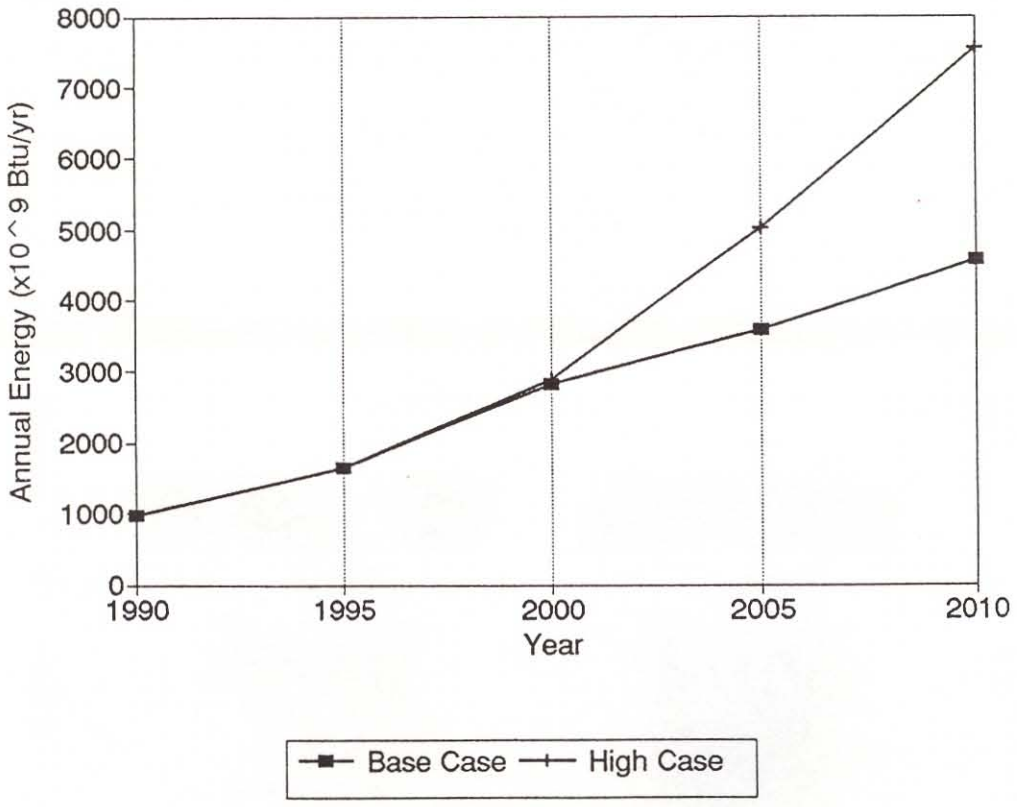

Figure 1. Geothermal aquaculture growth in the U.S.

Aquaculture can utilize geothermal resource temperatures as low as 70 (lower for trout, bass and salmon) to 80°F and can be cascaded from other uses. The number of resources with suitable water quality is undoubtedly very large, but little is known about them.

As suitable ambient temperature sites in traditional southeastern aquaculture states are used up, there will be movement to western states with geothermal resources if information and technology are available. An active program of resource definition to assure availability of adequate quality water, demonstration of technology and disssemination of information to the aquaculture industry would stimulate growth.

Growth for the base case, will see some movement toward western states. Traditional pond and raceway methods will be used, resulting in geothermal use growth being the same as projected for the industry –10%/yr thru 2000 and 5%/yr thu 2010 (USDA Aquaculture Report, 1989). High growth is based on assumptions that low-temperature resource data will be obtained and disseminated. High tech aquaculture (use of recirculating water systems and high stocking rates) will be demonstrated using geothermal to maintain temperature. Figure 1 illustrates the base and high case growth rates for aquaculture.

CONCLUSIONS

The potential for the utilization of geothermal energy in the aquaculture industry could be very large. The growth of the industry was substantial during a period when federal assistance provided resource location and confirmation programs. Low-temperature resource exploration and characterization are needed for large scale development in new resource areas.

REFERENCES

Fitzsimmons, K.M., 1988. "Status of Aquaculture in the State of Arizona", Klamath Falls, OR: Geo-Heat Center Quarterly Bulletin, Vol. 11, No. 1, pp. 23 to 24.

Lienau, P.J.; G. Culver and J.W. Lund, 1988. "Geothermal Direct Use Developments in the U.S.", report to the USDOE Idaho Operations Office: Geo-Heat Center, 107 pp.

Lund, J.W.; P.J. Lienau and G. Culver, 1990. "The Current Status of Geothermal Direct Use Development in the United States Update: 1985-1990", Davis, CA: GRC Trancsactions Vol. 14, pp. 277 to 291.