7.13 Freshwater fish seed resources in Mexico

Ana Bertha Montero Rocha
Secretaria de Agricultura, Ganaderia, Desarrollo Rural, Pesca y Alimentación
Instituto Nacional de la Pesca, Dirección de Investigación en Acuacultura Sanidad Acuícola
Pitágoras 1320, Sta Maria Atoyac, C.P.03310. México D.F.
abmontero@inp.sagarpa.gob.mx; anabmont1@yahoo.com.mx

Montero Rocha, A.B. 2007. Freshwater fish seed resources in Mexico, pp. 343–359. In: M.G. Bondad-Reantaso (ed.). Assessment of freshwater fish seed resources for sustainable aquaculture. *FAO Fisheries Technical Paper.* No. 501. Rome, FAO. 2007. 628p.

ABSTRACT

Aquaculture officially began in Mexico in the early 1970s, as an alternative to produce low cost food fish for rural communities. Tilapia, common and Chinese carps were introduced, reproduced in government fish hatcheries and fingerlings distributed to newly trained farmers for growing to small ponds throughout the country. Gradual private investment and the introduction and mastering of culture technologies for high value species, gave way to a new, growing and competitive industry, which yielded almost 80 000 tonnes in 2004.

Freshwater aquaculture production is mostly comprised of tilapia, which contributes more than 35 percent, common carp (11 percent), rainbow trout (1.7 percent) and channel catfish (1.15 percent) of the total national aquaculture production, the balance of production coming from marine species.

There are 165 registered hatcheries in the country, both public and private, whose total output is approximately 200 million fingerlings of the above species per year. Additionally, imports of eggs and fry from the United States of America, Canada and Europe, amount to between 17 and 20 million annually. Furthermore, the rapid expansion of the industry (25 percent per annum during the last 5 years), has stimulated the establishment of a growing number of hatcheries.

Breeding and hatchery techniques have been adapted from standard procedures developed and employed worldwide. In the case of tilapia, seed is produced in hatcheries that are vertically integrated and attached to medium- or large-sized ponds or cage farms. Breeders are stocked in earthen or concrete ponds or in cages (1-1.5 males per 2-3 females). In cages, artificial spawning floors are provided. Fry are transferred to sex reversal ponds and fed with hormonized feed to produce all-male cohorts.

Carp seed are produced chiefly by government hatcheries. Pituitary extracts are injected to breeders to induce spawning and are then maintained in 0.1-0.2 ha ponds. Fry are raised in earthen fertilized ponds until they reach 5-8 g and then distributed to growers.

Rainbow trout hatcheries are all part of vertically-integrated farms. Manual stripping of breeders and artificial dry insemination are employed. In addition, some farmers regularly import eyed-eggs to maintain genetic diversity. Weaned trout are reared within the farm to market size.

A few native species, such as *Cichlasoma urophthalmus*, are also bred in captivity employing natural methods (i.e. earthen ponds stocked with mature adults at a ration of 1 male:2-3 females and left to spawn naturally) and their seed regionally distributed to growers.

Pricing of fish seed in Mexico, especially of carps and tilapias, is generally biased given that government hatcheries sell these at subsidized prices, thus distorting the market. Mid- to large-sized farms produce their own seed. With the rapid growth of this sector, support services to the industry are also increasing. Genetic research and technical training are provided through government programmes. However, there are no genetic banks or genetic follow-up programmes. Farmer networks are not well consolidated, thus seed producers tend to work individually.

As far as seed quality is concerned, currently there are no official standards in the country. It is the buyers´ level of satisfaction in terms of seed performance (i.e. survival rate, growth rate, disease resistance, etc.) that determine acceptance or rejection of seed. Zoosanitary certification of seed is mandatory if eggs, fry or fingerlings are to be moved both within the country and internationally. Genetic improvement is only a part of research programmes, and links between scientists and farmers are still very weak.

INTRODUCTION

The information presented in this document is based principally on statistics published by the Federal Government which have been compiled and circulated to the fisheries sub-delegations in each of the states comprising the Republic of Mexico. Another source of information was the content of the statistical yearbook of fisheries, most recently published in 2003. The National Fisheries Map was prepared by the National Fisheries Institute (INP, Instituto Nacional de las Pesca) through the General Directorate of Aquaculture Research (Dirrecion General de Investigacion en Acuicultura) in coordination with the National Commission on Fisheries and Aquaculture (CONAPESCA, Comisión Nacional de Pesca y Acuicultura). Other institutions are devolved agencies of the Secretariat of Agriculture, Farming, Rural development, and Fisheries and Food (SAGARDP, Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación). Other sources include: (i) information which the state committees on aquatic animal health has compiled after visits to the producers; these committees are part of a tripartite structure of joint responsibility between producers and state and federal government, (ii) articles and presentations published in conferences, symposia, or events related to aquaculture and (iii) information from state governments.

In Mexico, aquaculture started as an activity which complemented social support to rural communities aimed at increasing the consumption of animal protein and improve the nutritional well-being of the population (Juarez-Palacios, 1987).

From its beginnings, there have been two development trends in aquaculture which reflect the different stages of aquaculture development in the country, namely: (i) promotional aquaculture and (ii) commercial aquaculture. Promotional aquaculture is applied in small bodies of water and production units, principally for domestic consumption using species such as tilapia and carp, as well as aquacultural fisheries activities such as systematic sowing, in medium- and large- sized reservoirs, of seed produced in state or federal-owned aquaculture centers and management of fish spawn where it occurs in the wild. The species most commonly seeded are carp, tilapia, catfish and bass (the latter for sport fishing). Commercial aquaculture, on the other hand, carried out in controlled systems using species such as trout and catfish, and later with tilapia, had the objective of obtaining high production levels, in order to become a viable commercial prospect, which inevitably demands greater investment (Ramírez and Sánchez, 1998).

Within the encouragement of aquacultural activity, some native species, such as silverside (*Chirostoma stor*) are primarily destined for re-stocking and to support rural communities.

The species currently farmed in Mexico, their final use and the infrastructure of the production systems are presented in Table 7.13.1.

TABLE 7.13.1
Cultured freshwater fish in Mexico

Species	Common name	Use	Production system	Infrastructure
Cyprinus carpio specularis	common carp	re-stocking, human consumption, aquarium	semi-intensive, extensive	natural and concrete ponds, cages
Cyprinus carpio communis	mirror carp	re-stocking, human consumption, aquarium	semi-intensive, extensive	natural and concrete ponds, cages
Cyprinus carpio rubrofuscus	pot-bellied carp	re-stocking, human consumption, aquarium	semi-intensive, extensive	natural and concrete ponds, cages
Carassius auratus	goldfish	re-stocking, human consumption, aquarium	semi-intensive, extensive	natural and concrete ponds, cages
Ctenopharyngodon idella	grass carp	re-stocking, human consumption, aquarium	semi-intensive, extensive	natural and concrete ponds, cages
Hypophthalmichthys molitrix	silver carp	re-stocking, human consumption, aquarium	semi-intensive, extensive	natural and concrete ponds, cages
Ariistichthys nobilis	bighead carp	re-stocking, human consumption, aquarium	semi-intensive, extensive	natural and concrete ponds, cages
Mylopharyngodon piceus	black carp	re-stocking, human consumption, aquarium	semi-intensive, extensive	natural and concrete ponds, cages
Atractosteus spatula	alligator gar	human consumption, sport fishing	extensive	natural ponds
Micropterus salmoides	largemouth bass, Patzcuaro trout	human consumption, sport fishing, handicrafts, biological control	Intensive semi-intensive, extensive	rustic reservoirs, natural and concrete ponds
Atractosteus tropicus	tropical gar	re-stocking, human consumption, sport fishing, handicrafts,	extensive	rustic reservoirs, natural and concrete ponds
Chirostoma estor	pike silverside	re-stocking, human consumption	extensive, controlled	natural and concrete ponds, plastic and galvanized tanks
Chirostoma humboldtianum	pescado blanco	re-stocking, human consumption	extensive, controlled	natural and concrete ponds, plastic and galvanized tanks
Chirostoma promelas	blacknose silverside	re-stocking, human consumption		
Chirostoma lucius	longjaw silverside	re-stocking, human consumption		
Chirostoma sphyraena	bigmouth silverside	re-stocking, human consumption		
Oreochromis aureus	blue tilapia	re-stocking, human consumption	intensive, semi-intensive, extensive	rustic reservoirs, natural and concrete ponds, cages
Oreochromis niloticus	Nile tilapia	re-stocking, human consumption	intensive, semi-intensive, extensive	rustic reservoirs, natural and concrete ponds, cages
Oreochromis mossambicus	Mozambique tilapia	re-stocking, human consumption	intensive, semi-intensive, extensive	rustic reservoirs, natural and concrete ponds, cages
Oreochromis urolepis homorum	Wami tilapia	re-stocking, human consumption	ntensive, semi-intensive, extensive	
Oncorhynchus mykiss	rainbow trout	re-stocking, human consumption, sport fishing	intensive, semi-intensive	natural and concrete ponds, cages, and fast-flowing channels
Ictalurus punctatus	channel catfish	re-stocking, human consumption	intensive, semi-intensive	natural and concrete ponds, cages, and fast-flowing channels

Source: INP SAGARPA (2003)

TABLE 7.13.2
Volume and Value of fish production though aquaculture, by principal species for 2003 (tonnes, value in pesos and dollars)

Species	Volume*	Value	
		1 000 pesos	US$
Total	**204 012**	**4 423 255**	**419 265 877**
Catfish	2 464	47 558	4 507 867
Carp	22 059	172,355	16 336 967
Silver side fish	812	5 416	513 365
Prawn	43	3 059	289 953
Bass	818	19 458	1 844 360
Tilapia	58 660	608 080	57 637 915
Trout	3 734	126 543	11 994 597
Others	5 428	711 974	67 485 687

Source: Annual Statistics of Fisheries (SAGARPA, 2003)

TABLE 7.13.3
Volume of aquaculture production of cultured live fish by principal species in 2003 (in tonnes)

Species	Total	Aquaculture	
		Controlled systems	Aquaculture fisheries
Total	207 776	74 039	133 737
catfish	2 516	497	2 020
carp	22 189	405	21 784
silverside fish	812	0.50	812
prawn	43	3	40
bass	848	3	845
tilapia	61 516	964	60 551
trout	3 734	3 483	251
others	5 466	4 562	904

Source: SAGARPA, 2003

The most recent statistics for aquaculture production in Mexico, from 2003 (Anuario Estadístico de Pesca, 2003) can be found in Table 7.13.2 and Table 7.13.3.

The growth of the population of Mexico has led also to a rise in the numbers living in extreme poverty, exacerbated by poor diet with low levels of nutrition. Aquaculture has the potential to provide an alternative diet through production of products with good quality protein that will help diminish malnutrition in this vulnerable sector of society.

Mexican statistics reveal that the annual average per capita consumption of fish, between 1992 and 2002, was 12.47 kg (SAGARPA, 2002) which falls below the minimum annual requirement of 20 kg.

Although rural aquaculture programmes do exist in zones of lesser economic development and high levels of poverty, a limiting factor on their expansion is the lack of interest in the sector, the lack of tradition of eating fish, as well as the lack of information on the benefits of eating fish. It is thus essential to have more solid and continuous programs of expansion for aquaculture.

SEED SUPPLY AND RESOURCES

Seed are produced from state and federal as well as private hatcheries. Seed of the following species are produced: trout, carp, tilapia, catfish, bass, silver carp.

In order to help the population living in poverty, the production of 39 hatcheries operated and supervised by CONAPESCA had been sent to 608 municipalities, of which 51 percent are highly marginalized. This has benefitted 126 000 families through improvement in the quality of their nutrition and income generation through fish sales (SAGARPA, 2004).

The national program of support to rural aquaculture promoted the development of aquaculture in marginalized areas through the supply of fingerling, technical assistance and delivery of resources for the renovation or construction of infrastructure, acquisition of equipment and provision of contracts for specialized technical assistance. As a result of this program, 11 541 families in the most marginalized regions of the country benefited in 2001. Ponds are stocked with 13 million fry for the production of carp, catfish, and tilapia. In 2003, beneficiaries of the program included 4 129 producers located in 239 communities in 110 municipalities in the country (SAGARPA. 2004).

SEED PRODUCTION AND TECHNOLOGY

Table 7.13.4 shows the production technologies of different species in different states.

TABLE 7.13.4
List of federal government, state government, private and commercial hatcheries

Trout

State	Hatchery	Technology used	Fry production
Baja California	Private	Artificial spawn	No data home consumption
Chihuahua	hatchery de Guachochi[1]	Artificial spawn	636 350 520 000*
	hatchery de Madera[1]	Artificial spawn	Not in production at present
Mexico	hatchery "El Zarco"[1]	Artificial spawn	Not in production at present
	hatchery Calimaya[2]	Artificial spawn	Not in production at present
	58 private producers[4]	Artificial spawn	2 000 000
	Private importers[3]	Eyed eggs importation from USA and Australia	7 000 000 eyed eggs dead are not considered
Hidalgo	La trucha de "El Zembo"[4]	Hatchery. Egg incubation, imported form USA	450 000
	Worker´s Cooperative "La trucha de San Diego"[4]	Hatchery. Egg incubation, imported form USA	75 000
	Worker´s Cooperative acuícola "Apulco"[4]	Hatchery. Egg incubation, imported form USA	64 000
	S.P.P. de San Miguel Regla	Artificial spawn	No data
Michoacán	hatchery Pucuato[2]	Artificial spawn	170 606
Puebla	hatchery Apulco[1]	Artificial spawn	2 000 000 750 000*
	hatchery "La Rosita"[2]	Artificial spawn	1 000 000 750 000*
	Private hatchery Xoulin[3]	Artificial spawn	No data home consumption
	Commercial sector	Artificial spawn	450 000*
	Private sector	Artificial spawn	300 000*
Veracruz	hatchery Matzinga[1]	Artificial spawn	Not in production at present

Total production of the trout fry reported from federal government hatcheries in 2004 were 1 025 156 CONAPESCA.

* No official data, from aquatic health aquaculture committee, state government, universities and general publication, etc.

Carp

State	Hatcheries	Technology used	Fry production
Aguascalientes	Hatchery Pabellón de Hidalgo[1]	Artificial spawn and induced	1 211 500
Chiapas	Hatchery San Cristóbal[1]	Artificial spawn and induced	336 156 1 650 000*
Chihuahua	Hatchery La Boquilla[1]	Artificial spawn and induced	326 000 287 150*
Coahuila	Hachery La Rosa[1]	Artificial spawn and induced	6 821884 5 700 000*
Durango	Hatchery Valle de Guadiana[1]	Artificial spawn and induced	2 824 450 4 000 000*
Guanajuato	Hatchery Jaral de Berrio[1]	Artificial spawn and induced Artificial spawn and induced	3 356 500
	Hacthery Martín Magaña[3]		No data
Hidalgo	Hatchery Tezontepec de Aldama[1]	Artificial spawn and induced	31 403 531
	Integral farm of Poli- culture Tezontepec[2]	Artificial spawing and induced	6 082 000
Jalisco	Hatchery Tizapan El Alto[1]	Artificial spawn and induced	335 950
	Hactchery Las Pintas[1]	Artificial spawn and induced	No data
Michoacán	Hacthery Pátzcuaro[1]	Artificial spawn and induced	45 850 1 075 000*
	Hatchery Zacapu[1]	Artificial spawn and induced	2 104 389 1 500 000*
Estado de México	Hatchery Tiacaque[2]	Artificial spawn and induced	14 000 000
	Hatchery La Paz[2]	Artificial spawn and induced	711 000
Puebla	Hacthery "La Rosita[2]	Artificial spawn and induced	1 000 000
Querétaro	Hatchery Calamanda[1]	Artificial spawn and induced	161 250 750 000*
	Hatchery Conca[2]	Artificial spawn and induced	348 000*
San Luis Potosí	Hatchery El Peaje[1]	Artificial spawn and induced	509 000
Sonora	Hatchery Cajeme[1]	Artificial spawn and induced	No data
Tamaulipas	Hatchery Tancol[1]	Artificial spawn and induced	No production at present
Tlaxcala	Hatchery Atlangatepec[1]	Artificial spawn and induced	750 000

Total carp fry production reported from federal government hatcheries CONAPESCA 2004, were 52 578 139

* Unofficial data, from the aquatic animal health committees, state government, universities, scientific publication, etc.

Tilapia

State	Hatchery	Technology used	Fry production
Aguascalientes	Hatchery Pabellón de Hidalgo[1]	Natural spawn	5 716 000
Baja California	Private	Natural spawn	Home consumption
Campeche	State	Natural spawn	800 000 fingerling/month*
Chihuahua	Hatchery "La Boquilla"[1]	Natural spawn	187 950 217 900*
Coahuila	Hachery "La Rosa"[1]	Natural spawn	370 919 660 000*
Colima	Hatchery "El Saucito"[1]	Natural spawn	434 449
	Hatchery "Jala"[1]	Natural spawn	2 314 717
	ha Potrero Grande[1]	Natural spawn	10 000
Chiapas	Hatchery Benito Juárez[1]	Natural spawn	1 140 700
	Hatchery El Pataste[1]	Natural spawn	262 000
	Hatchery San Cristóbal[1]	Natural spawn	No data
Chihuahua	Hatchery La Boquilla[1]	Natural spawn	187 950
	Hatchery Guachochi[1]	Natural spawn	No data
Durango	Hatchery Valle de Guadiana[1]	Natural spawn	289 833
Estado de México	Hatchery La Paz[2]	Natural spawn	2 250 000
Guanajuato	Hatchery Jaral de Berrio[1]	Natural spawn	264 166
Guerrero	Hatchery Aguas Blancas[1]	Natural spawn	437 900
Hidalgo	Hatchery "Acuicultores de Tollan[4]	Natural spawn	1 500 000 fry 40 percent for state consumption. To cover the full demand, suppliers are from Morelos, Oaxaca and Michoacán states.
	Hatchery Tezontepec de Aldama[1]	Natural spawn	This year begins the fry production. No data for planned production
Jalisco	Hatchery Las Pintas[1]	Natural spawn	No data 1 800 000*
Michoacán	Hatchery Pátzcuaro[1]	Natural spawn	No production
Morelos	Hatchery El Rodeo[1]	Natural spawn	1 640 660
	Hatchery Zacatepec[1]	Natural spawn	957 668
Nayarit	Hatchery San Cayetano[1]	Natural spawn	373 350
Oaxaca	Hatchery Temascal[1]	Natural spawn	3 905 050
Querétaro	Hatchery Calamanda[1]	Natural spawn	162 250 1 324 000*
Quintana Roo	Private		300 000 fingerling/month*
Sinaloa	Hatchery Chametla[1]	Natural spawn	5 938 400
	Hatchery El Varejonal[1]	Natural spawn	10 387 000
Sonora	Hatchery Cajeme[1]	Natural spawn	No data
	Worker´s cooperative La Laguna del Río[4]	Fingerling importation	Fingerling importation 950 000
Tabasco	Hatchery Puerto Ceiba[1]	Natural spawn	1 520 866
Tamaulipas	Hatchery Tancol[1]	Natural spawn	265 200 349 400*
Veracruz	Hatchery La Tortuga[1]	Natural spawn	1 049 500
	Hatchery Los Amates[1]	Natural spawn	262 090
	Hatchery Sontecomapan[1]	Natural spawn	1 816 402
	Hatchery Tebanca[1]	Natural spawn	72 894
Zacatecas	Hatchery Julián Adame[1]	Natural spawn	811 000

Total tilapia fry production reported from federal government hatcheries CONAPESCA 2004, were 43 813 964.

* Unofficial data, from the aquatic animal health committees, state government, universities, and scientific publication.

Bass

State	Hatcheries	Technology used	Fry production
Aguascalientes	Hatchery Pabellón de Hidalgo[1]	Natural spawn and induced	254 400
Coahuila	Hatchery La Rosa[1]	Natural spawn and induced	52 376 47 000*
Chihuahua	Hatchery La Boquilla[1]	Natural spawn and induced	No data
Durango	Hatchery Valle de Guadiana[1]	Natural spawn and induced	96 123 100 000*
Estado de México	Hatchery La Paz[2]	Natural spawn and induced	23 000
Michoacán	Hatchery Pátzcuaro[1]	Natural spawn and induced	Not in production
Sinaloa	Hatchery El Varejonal[1]	Natural spawn and induced	No data
Sonora	Hatchery Cajeme[1]	Natural spawn and induced	No data
Tamaulipas	Hatchery Tancol[1]	Natural spawn and induced	23 230

Total bass fry production reported from federal government hatcheries CONAPESCA 2004, were 426 129.

* Unofficial data, from the aquatic animal health committees, state government, universities and scientific publication.

Catfish

State	Hatcheries	Technology used	Fry production
Coahuila	Hatchery La Rosa[1]	Natural spawn and hormone induced	268 271 181 000*
Chihuahua	Hatchery La Boquilla[1]	Natural spawn and hormone induced	845 500 675 000*
Durango	Hatchery Valle de Guadiana[1]	Natural spawn and hormone induced	No data
Guanajuato	Worker´s cooperative Granja El Geranio[4]	Natural spawn and hormone induced	No data
Michoacán	Hatchery Huingo[2]	Natural spawn and hormone induced	No data
Sonora	Hatchery Cajeme[1]	Natural spawn and hormone induced	No data
San Luis Potosí	No data	Dato no disponible	No data
Tamaulipas	Private Criadores Acuícola de Tamaulipas S.A de C.V[3]	Fingerling importation	150 000
	Acuamex[3]	Natural spawn and hormone induced	No data

Total catfish fry production reported from federal government hatcheries CONAPESCA 2004, were 1 113 771.

* Unofficial data, from the aquatic animal health committees, state government, universities and scientific publication.

Native silverside fish

State	Hatcheries	Technology used	Fry production
Jalisco	Hatchery Tizapán El Alto[1]	Natural spawn	4 000
Michoacán	INERENA[2]	Natural spawn	No data
	CRIP Pátzcuaro[1]	Natural spawn	65 000

Catán

State	Hatcheries	Technology used	Fry production
Tamaulipas	Hatchery Tancol	Natural spawn	79 900 35 000*

* Unofficial data, from the aquatic animal health committees, state government, universities and scientific publication

SEED MANAGEMENT

This section provides a brief description of seed management protocols for each species.

Trout. There is no management of broodstock. In general, they are not provided with food specific to their requirements. Young are fed according to size; the selection of food according to size is often deficient. There is no sanitary management program in rearing farms. In intensive farms, there are programmes for sanitary management which include preventative measures such disinfection of equipment.

Carp. At breeding time, the organisms are given vitamins in commercial preparations, supplemented by alfalfa. Hypophysis extracts are used to induce spawning. There is no programme for genetic management. There are preventative programmes and sanitary management in seed production centers which are federal or state-run.

Tilapia. There are no sanitary management schemes in commercial farms. Seed are separated in ponds and given hormone-supplemented feed for approximately one month.

Catfish. No available information.

Native silverside fish. There is no programme on genetic modification. Feed for larvae include cultivated algae, rotifers.

Bass. No information available.

SEED QUALITY

Federal and state hatcheries have qualified personnel who could apply preventative treatment, health management and hygiene programs in hatcheries during fry production. Frequently used chemicals include sodium chloride, formalin, malachite green and methylene blue. Other preventative actions include restricted access, smooth walls, treatment of water discharge and foot baths.

Since genetic programmes are still being developed, few options exist for assuring quality of fry in terms of growth rates, uniformity of size, survival, etc. Trout normally has 20 percent mortality of eggs produced.

SEED MARKETING

Fry sales generally occur in hatchery facilities. There is no specific way to distribute fry; there are intermediaries who buy and sell fry to farms which are distantly located from hatcheries. These intermediaries usually act individually. On the other hand, rural fish farmers go to hatcheries to purchase or receive (in case of donations) fry. These facilities are financed by the federal and state governments to support rural aquaculture. There is no information about financing support for farmers for fry

TABLE 7.13.5

Price of fry depend on size and the structure of production facility

Type of Facility	Trout		Carp		Tilapia	
	Cost per thousand or unit (Mexican pesos)	Size	Cost per thousand or unit (Mexican pesos)	Size	Cost per thousand or unit (Mexican pesos)	Size
Private	600.00	6 cm			$ 0.15	inch
Private	1 000.00	4 - 5 cm.				
Private	0.70	I in				
Hatchery State government	400.00	4 cm	donation			
Hatchery Federal government	0.11 0.27 0.21	trout to centimeter trout inch eyed eggs unit	$ 110.00	4 cm	$ 0.16 0.31 $ 110.00 $ 165.00	inch inch 4 cm 4 cm
Social sector					$ 0.30	inch
Social sector					$ 0.15	inch

Type of Facility	Catfish		Bass	
	Cost per thousand or unit (Mexican pesos)	Size	Cost per thousand or unit (Mexican pesos)	Size
Hatchery Federal government	$ 0.31	Inch	$ 1.28	inch

PLATE 7.13.1
Tilapia aquaculture systems in México

Tilapia

Tilapia fry

Cage production system

Confinement production system

Semi-intensive production system

Intensive production system

PHOTOS COURTESY OF TABASCO STATE HEALTH COMMITTEE (CESAT)

production or importation of eyed-eggs for hatcheries. The market is generally stable and not much fluctuation in prices. Price of fry depend on size and the structure of production facility as shown in the table below:

SEED INDUSTRY

Trout. In the trout hatchery industry, there are small-scale producers producing between 3 000 to 30 000 seed; medium-scale producers producing between 30 000 to 100 000 seed and large-scale producers whose production is between 100 000 to one million seed; the latter are represented by federal and state and some private

PLATE 7.13.2
Practical training courses provided by state and federal agencies to rural fish producers in Mexico

hatcheries. One of the main problems during the production of trout fry is the lack of eggs during summer due water temperature; all eggs supplied during this season are imported. A mechanism adapted by the trout industry, at present, is to import eyed-eggs incubated in hatcheries and set on sale as fry to the market. National egg production is not stimulated although a great demand for fry exists in the market. In order to be profitable, fry production must be on a grand scale. Prices are more or less stable. Sale of fry to distant farms are made by intermediaries, but these are rather uncommon. Seed are provided to the rural sector through government-supported programs to the aquaculture industry or through federal and state government donations. There is no data available about the participation of women in this activity.

Carp. The different carp species are practically produced in its totality by the state and federal hatcheries, which can be considered as large-scale producers. The production of fry, as commented earlier, in most cases is made through donation of seed for stocking in dams or to maintain the subsistence of aquaculture or for home consumption. The price that federal government, at the moment, has fixed for the fry is with a very high subsidy and price is rather symbolic. In economic terms, a farmer does not face any financial issues such as low price, seasonality, weather conditions, distance between suppliers and markets, etc., since fry is mainly government-produced.

Tilapia. Production of tilapia occurs in medium- and large-scale, the latter in private farms or in the federal and state governmental facilities. Meanwhile, medium-scale farming occurs in the social sector. The hormone-treated fry used for monosex production is attracting more interest and demand from producers as is as the red variety because of its pleasing aspects. It appears that climate has no favourable or unfavourable effect on the production of fry throughout the year. The sale mechanism is the same as for those of trout, where farmers come to hatchery facilities to buy fry directly. It is possible that there are some intermediaries, but at present there is no information about the existence of unions or associations. The price of fry depends on

the source (i.e. government, social, or private). Acquisition of fry for rural aquaculture or simply for subsistence, in many states in the country, is through government donation or through different support programs already established for farms in the rural sector. There are no official statistics on fry production in private hatcheries. However, numbers have been increasing in the states of Jalisco, Colima and San Luis Potosí. It is probable that fry production from social and government facilities could be related to home consumption. Many private companies have imported broodstock from Colombia. The participation of women in this area is not recorded or registered in any document.

Catfish. With regard to catfish production, there is little information, probably because broodstock decreased during the last decade. The size of fry production by government centers is medium-scale and there is no data or information from private producers who, probably, produce only for home consumption. The authorized price for selling fry is based on those authorized by federal governmental hatcheries. According to information given by the state aquaculture health committee, catfish fry comes from San Luis Potosí and Tamaulipas and the price is only the one authorized by the federal government. There is no information about the existence of intermediaries or network distribution. Apparently there are no weather condition problems affecting fry production, due to the fact that the country has an ideal climate for its reproduction. Five percent natural mortality is the normal occurrence for catfish fry. At present catfish culture is mainly located in the northeast and central plateau of the country. There is no information about the acquisition of the fry by the social and rural sectors. A recent problem has been the high mortality due to a viral pathogen.

The fry of other species such as native silverside fish, catán and pejelagarto, are not commercialized, they are generally donated to the rural communities and farmers. These centers of production are federal, state or university stations of investigation. Its production is still in an early stage since oftentimes there is no complete knowledge on techniques for reproduction, methods of feeding and handling in culture conditions of the species, in some stages of their life cycle like reproduction and feeding.

SUPPORT SERVICES

State governments have programmes on aquaculture development, technical advice and capacity building. State government hatcheries provide fry to rural aquaculture with 100 percent subsidy. At the federal level, three government agencies under SAGARPA are responsible for rural and social aquaculture. Each one is briefly described below:

CONAPESCA. This institute teaches courses and provides technical support. In the 1980s, it published an important manual aimed at social producers. The manual included all aspects of culture of trout, catfish, carp and tilapia. At present, the manual is being re-introduced including sections on good production practices and food quality. However, there is less information available for freshwater fish species compared to shrimp, for example.

SENASICA. This agency provides national services concerning health, agriculture and cattle food quality, The new General Law of Sustainable Aquaculture and Fisheries (2007) has given it the responsibility for national aquatic animal health services. Recently SENASICA has shaped the state aquaculture health committee as an auxiliary body. This committee has a tripartite structure, where federal and state governments and producers contribute equal amount of money for the committee's activities. Their own personnel are contracted including producers or other related professionals to fulfill farm level health management programs. At the moment, there are 19 aquaculture health committees in the 19 states of Mexico. The work program of the committee

includes the following: (i) development of technical and administrative structure of the committee in accordance with the state necessities to support the aquaculture industry; (ii) assessment of the health and sanitary status of farms; (iii) development of sanitary and health programs for fry production and distribution and (iv) promotion of good production and management practices in farms. With these objectives, farms are visited and samples collected. Technical support on main fish pathogens, treatments and good production practices are provided. Training courses (practical and theoretical) are also given on subject areas such as risks and diseases in tilapia farming, pathology and nutrition of carps, good aquaculture production practices in trout. Pamphlets and manuals about regulations are also produced.

INAPESCA (formerly INP). This institute has the responsibility for coordinating and guiding the scientific and technological research in the field of aquaculture and fisheries as well as the transfer of innovation and technology to the fisheries and aquaculture sector at the national level. This is achieved by the Regional Centers for Fisheries Research (Centros Regionales de Investigacion Pesquera) working and addressing the problematic situations in fisheries and aquatic farms. They serve as advisers to the aquaculture production cycle by evaluating the farm situation and implementing research and transfer technology programmes in different areas such as health management, infectious and parasitic disease diagnosis, nutrition, reproduction and genetics. The work is carried out jointly with CONAPESCA, SENASICA, the state aquaculture health committees, research institutions and universities.

SEED CERTIFICATION

At present, the most significant effort concerning seed certification is in trout fry, mainly through the state aquaculture health committees, in coordination with the state and federal governments. The work carried out in species like catfish, carp or tilapia is going more slowly, with little action concerning those species, since the market value is lower than trout. A regulatory framework for this activity was released in July 2007 and will be the responsibility of SENASICA. The previous inspection of trout fry before mobilization, has given us knowledge about the health status of the fry population which became one of the basis for setting the criteria to recognize the health status of zones. This can allow the designation of zones free of pathogens, in the case of trout, for instance, the infectious pancreatic necrosis virus (IPNV).

LEGAL AND POLICY FRAMEWORKS

Legal Framework for Aquaculture

The legislation is based on the Mexican Constitution, the General Law of Sustainable Aquaculture and Fishery (Ley General de Pesca y Acuacultura Sustentable, July 2007)) and its regulation, the General Law of the Ecological Balance and all those rules that legislate the aquatic field and exploitation of the natural resources.

General Law of Sustainable Aquaculture and Fishery Regulation

The new General Law of Sustainable Aquaculture and Fishery is still under review and has not yet been published, therefore the description in this document refers to the previous law, where the third paragraph, Chapter 1, makes reference to the general layout of aquaculture (Articles 101 to 105). Chapter 2 refers to commercial aquaculture, specified in Articles 107 and 108 the requirements for this kind of concessions in waters with federal jurisdiction. Chapter 3 refers to the development of aquaculture (Articles 114-119), where the requirements for this kind of concession are specified. In Chapter 4 (Articles 120-124) didactic aquaculture is mentioned including the requirements for its authorization. The introduction of live species in water bodies of federal jurisdiction is covered in Chapter 5 (Articles 125-127) which outlines the detailed

information required. Chapter 6 (Articles 128-136) refers to aquatic animal health management. This section layout the aquatic animal health certification requirements, for importation of live aquatic species (animals or plants) to the national territory. This certificate must be issued by the competent authority of the country of origin. In this section, quarantine specifications of the imported species and the actions to be carried out at the final destination are also described. In order to be able to move the species from the quarantine, an aquatic animal health certificate has to be obtained from the Ministry (General Law of Sustainable Aquaculture and Fishery's Regulation, 2007).

However, todate there is no specific legal framework to support and regulate the production of fresh water fish species fry. The importation of trout eyed-eggs or fingerlings are regulated under the Official Mexican Norm NOM-010-PESC-1993, which establishes the sanitary requirements for the import of live aquatic organisms in any stage of development, destined for aquarium exhibition or aquaculture activity in the national territory. NOM-011- PESC-1993 regulates the application of quarantine in order to avoid the introduction of diseases from imported aquatic organisms.

ECONOMICS

There is no available data on profitability, supply, demand, prices, factors that determine the price of the seed, or the economic contribution of the activity from producers, since the economic studies are not available in fry production. The existing data refers to the value of fish meat production.

Seasonality production of trout fry is the most important issue, because there is no year-round production, therefore the importation of summer eggs is a profitable business since in Mexico we do not have the technology to apply delayed spawning (photoperiod) method in order to get summer eggs. Therefore there is a high risk of introducing imported diseases. A research project is addressing photoperiod technology with the aim of having egg production throughout the year and minimizing the risk of disease introduction through importation.

An analysis of the economy of fry production should be considered, since state and federal hatcheries frequently donate fry to the rural communities, or the price is highly subsidized. This situation could be one of the reasons why the rural or private sector of fry production have not grown and may not be a profitable option, since the larger farms generally produce their own fry.

INFORMATION OR KNOWLEDGE GAPS

There is a lack of specific regulation for different genus or species, supporting and establishing health and production norms, including all stages of development, from egg, fry, fingerlings until commercial size, as well as for health management and good aquaculture production practices. There is a lack of diagnostic laboratory services for monitoring the health status of the reared fry, as well as farm status certification programs through a sampling plan, in order to achieve a certified broodstock population which will ensure the production of healthy fry. Genetic research projects with the target of improving seed quality are also lacking.

STAKEHOLDERS

Local institutions are represented by the State Aquaculture Health Committees, as well as the state and federal government, who offer services for field work and technical assistance. There appears to be no association of producers of freshwater fish. This scheme only exists in Mexico in the shrimp production sector, where the National Association of Producers of Larvae of Shrimp, ANAPLAC, represents the shrimp hatchery interest and points of view.

Listed below are some of the stakeholders in the freshwater fish seed sector in the country.

Small hatcheries. Concerned with development of local market. Some social centers of production of fry exist that sell fry locally.

Large hatcheries. Concerned with the development of new varieties/strains or innovations. They do not exist at the moment. In trout the aquaculture production center 'El Zarco' operated by the federal government, has the project to turn the center into a center of excellence for the production of quality fry with specific genetic programs for survival size, appearance and resistance to diseases and at the same time to establish technology for egg production during summer.

Associations. Concerned with representing the interests of the industry. No existing associations of freshwater fish fry; however, associations of producers of trout, catfish and tilapia exist.

Government institutions. Concerned with offering legal and political frameworks to the industry involved in seed production and seed marketing as well as offering extension services. As previously mentioned, the main institutions are SAGARPA, CONAPESCA, SENASICA, INAPESCA and DGIA.

Researchers. Universities and research institutions concerned with information, knowledge and technology generation. A great number of academic and research institutions exist in Mexico, carrying out projects relative to species of fish of freshwater culture, in the areas of genetics, nutrition, diagnosis of the infectious agents, summer egg production, standardization of diagnosis techniques, etc. These institutions acquire resources through the National Council of Science and Technology (CONACYT), as

TABLE 7.13.6
Institutions that carry out aquaculture research projects

Level	Universities or research centers
University	Instituto Politécnico Nacional Escuela de Biología
	Instituto Tecnológico de Monterrey
	Instituto Tecnológico del Mar No. 1 de Veracruz
	Instituto Tecnológico del Mar No. 6 de Nayarit
	Universidad Autónoma de Aguascalientes
	Universidad Autónoma de Baja California (UABC)
	Universidad Autónoma de Baja california Sur
	Universidad Autónoma de Campeche (UAC)
	Universidad Autónoma de Jalisco
	Universidad Autónoma de Nuevo León (UANL)
	Universidad Autónoma de Yucatán
	Universidad Autónoma Metropolitana (UAM-Xochimilco y UAM –Iztapalapa
	Universidad de Occidente (UDO)
	Universidad de Sonora (UNISON)
	Universidad Juárez Autónoma de Tabasco (UJAT)
	Universidad Nacional Autónoma de México (UNAM) Facultad de estudios superiores FES – Unidad Iztacala
Research centers	Centro de Investigación en Alimentación y Desarrollo (CIAD) CIAD Mazatlán y hermosillo
	Centro de Ciencias de Sinaloa (CCS)
	Centro de Investigaciones Biológicas del Noroeste (CIBNOR)
	Centro de Investigación Científica y de Educación Superior de Ensenada (CICESE)
	Centro de Investigación y estudios avanzados del Instituto Politécnico Nacional CINVESTAV – Unidad Mérida
National Fisheries Institute Regional Centers of Fishing Research(CRIP)	CRIP – Unidad Pátzcuaro
	CRIP – Unidad Veracruz
	Dirección General de investigación en acuacultura

well as cooperation with projects of the state and federal governments, who promote the necessary lines of investigation to support aquaculture. Table 7.13.6 lists the different institutions that carry out aquaculture research projects.

Institutions that offer postgraduate studies (Masters and Doctorate degrees) in aquaculture are: (i) Marine Technological Institute No. 1 of Veracruz, (ii) Biological Research Center of the Northwest (CIBNOR), (iii) Research Center for Nutrition and Development (CIAD), (iv) Scientific Superior Education and Research Center of Ensenada (CICESE) and (v) Research Center and Advanced Studies of the National Polytechnical Institute (CINVESTAV, Mérida Unit).

Donors. Concerned about financing projects. At present, development agency providing support to the freshwater fish production sector in the Japanese International Cooperation Agency (JICA). Ongoing projects supported by JICA include that of feeding requirements of white fish and provision of expertise to develop technologies for breeding of trout outside its breeding season.

FUTURE PROSPECTS AND RECOMMENDATIONS

Production of fish for rural communities or home consumption is covered by federal and state hatcheries. This could be the reason why the fry production business is not a very attractive activity although it has the potential to be profitable. There is no tradition of eating fish in Mexico even though the market price is quite good for consumers when compared with other protein sources like cattle, chicken or pork. A strong educational program is needed in rural communities, to demonstrate the nutritional advantages of having fish in their diet, as well as the bonus of an extra money by selling the product. While several programs exist to support rural aquaculture, there exist no follow-up programs or appropriate training courses for rural farmers. If such kind of training are made available, rural farmers will be able to operate their own farms. Heavy government subsidy does not provide encouragement for self-sufficiency.

There are few benefits or financial support from state or federal governments for fry producers, or for new hatcheries. A clear example is the lack of hatcheries since the demand for trout fry are met through importation of eyed-eggs from the United States of America.

On the other hand, it is very important set up effective mechanism to collect information and this database must be regularly updated. Although registers of fry production at the state and federal hatcheries exist, these data do not reflect the impact that they could have in rural aquaculture. It seems that it is important that this information is obtained from all hatcheries from governmental, private, social or rural sectors, for proper evaluation of fish farm performance.

Communication and co-operation between federal and state governments concerning aquaculture is very poor and some times is non-existent. While production data are reported by both bodies, the data collected do not coincide. In the same way, federal publications does not describe all state hatcheries, for instance, the carp fry producer hatchery Tiacaque at the state of Mexico which produce almost 95 percent of carp fry, is not considered in the National Fishing Map. The lack of a good information system is reflected as well in specialized magazine reports, which presents private hatcheries facilities for freshwater fish fry, but are not registered by the federal government. This is one of the main problems facing the administration of the aquaculture industry, since many producers do not have the registry of the CONAPESCA. This situation is being gradually resolved through the actions of the state aquaculture health committees, who have been doing survey work in state hatcheries, thus, giving a much better picture of the real aquaculture development in each province.

REFERENCES

Álvarez, T.P. 1996. Analysis of the production and research problematic in continental waters in Mexico, pp. 25-31. *In* Memories of the second meeting of the Nacional network of aquaculture researchers working in continental waters. Pátzcuaro, Mich. Instituto Nacional de la Pesca. Mexico D.F.

Álvarez, T.P. 2000. Institutional frame of Aquaculture development in Mexico, pp. 1-16. *In* State of the Aquaculture health. Álvarez-Torres, P., M. Ramírez-Flores, L.M. Torres-Rodríguez y A. Díaz de León-Corral (ed). Instituto Nacional de la Pesca, Mexico D.F.

Arredondo, J.L. & Lozano, S.L. 2003. Aquaculture in Mexico. Universidad Autónoma Metropolitana – Iztapalapa. México D.F. 266 pp.

Camacho, E., Luna, C. & Moreno, M.A. 2000. Guide to aquaculture of tilapia. Secretaría de Medio Ambiente, Recursos Naturales y Pesca. México D.F. 136 pp.

Carta Nacional Pesquera. 2004., Aquaculture 4th section. Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación. Official Diary of the Federation, volume DCVI No. 11, Mexico D.F. 25-61 pp.

Juárez-Palacios, R.R. 1987. Aquaculture in Mexico, Social and economic importance. In: Mexican Fisheries development. 1986-1987. Secretaría de Pesca. México D.F. Book II: 219-232.

Ley de Pesca y su Reglamento. 1999. Aquaculture, third title. Secretariat of Environment, Natural Resources and Fisheries, Mexico D.F. 15 pp.

Monroy S., 2003. Recirculation system for tilapia production: a case in the mexican southeast. In: Tilapia Nacional Meeting. Guadalajara Jalisco del 19 al 21 de marzo de 2003. SAGARPA, Instituto Nacional de la Pesca. México D F. 16 pp.

Portilla J.A. 2002. Trout production challenge in Mexico, pp. 87-88. *In* Trout Nacional Meeting 15-16 de agosto Toluca, Estado de México, 2002. SAGARPA, Instituto Nacional de la Pesca. Mexico D.F.

SAGARPA. 2001. Sectorial Program of Agriculture, Livestock Rural Development, Fisheries and Food 2001-2006. Ministry of Agriculture, Livestock, Rural development, Fisheries and Food. Mexico D.F. 17 pp.

SAGARPA. 2002. Statistic Annual of Fisheries 2002. Ministry of Agriculture, Livestock, Rural development, Fisheries and Food. Mazatlan, Mexico. 67 pp.

SAGARPA. 2003. Statistic Annual of Aquaculture and Fisheries 2003. Ministry of Agriculture, Livestock, Rural development, Fisheries and Food. Mazatlan, Mexico. 66 pp.

SAGARPA. 2004. Fourth Inform of activities 2004. Ministry of Agriculture, Livestock, Rural development, Fisheries and Food. Mexico D.F. 28 pp. (www.sagarpa.gob.mx)