Overview of Aquaculture in Mexico: Biomass Production and Research

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ABSTRACT

Mexico has 11,500 km of littoral zone. Fishery production in 1994 was 1,260 ,019 metric tons (mt) with aquaculture contributing 171,389 mt. Species traditionally reared in Mexico are trout, catfish, eastern oyster, carp, tilapia and freshwater crayfish. Many aquatic species have been cultured on an experimental and/or pilot scale. However, only a few species have reached commercial-scale development, including mojarra (47%), American oyster (22%), carp (14%) and shirmp (10%). Only shrimp and a little quantity of oyster were produced by a intensive aquaculture. The other 90% aquaculture production is produced by extensive aquaculture.

Mexico has 79 institutions in Marine Science or Biology, which 23 have been working with 60 aquatics species, and they have produced 162 scientific manuscripts (Science Citation Index). These results show few studies for anyone aquatic species. 52 studies were conducted on shrimp (*Panaeus vannamei* = 47 studies, 30.3%), 51 papers (32.9%) on mollusks (*Haliotis* = 15 papers, 10.3%), 28 on fish (14%), scallops (*Argopecten ventricosus* = 13 papers) and queen conch (*Strombus gigas* = 10 studies). Marine fishes and freshwater fishes have been less studied. Seventeen subject areas were identified; nutrition was the most studied (32 studies), while others included pollution, physiology, reproduction, etc. Mexico does not have an academic institution specializing in aquaculture, and so it begs the question. What is better for developing the aquaculture industry in Mexico? — to have Institutes specializing in particular subject ares,, or to have Research Institutes with many specialists?.

KEY WORDS: Aquaculture, Mexico

OVERVIEW OF THE AQUACULTURE IN MEXICO

Mexico and its Littorals

Mexico has 11,500 km of littorals and an exclusive economic zone of 2,892,000 km^2, which is larger than the entire Mexican Republic territory. Mexico is bordered by the Gulf of Mexico to the east, the Caribbean Sea to the southeast, and the Pacific Ocean and Gulf of California to the west.

Fish Production in Mexico

The most significant Mexican fishery production was 1,565,465 metric tons (mt) in 1981. Subsequently, fishery production has achieved the same volume; fishery production in 1994 was 1,260,019 mt, 19.5% lower than 1981. Since 1992, fishing activity was conducted by only 1.3% of the total population.

Mexico has a large market for seafood products. Tuna represents the largest share of the Mexican catch, estimated at 106,000 mt. Other important seafood products include shrimp, mojarra, and sardines. Domestic consumption of seafood was 692,000 mt in 1997, approximately 7.9 kilograms per person (Gand 1997). Both production and consumption fell 18% between 1991 and 1997, and exports declined from 58,000 to 37,000 metric tons.

Global Fisheries Production by Aquaculture

In the last century, world marine fisheries production has increased 25 fold from around three million tons at the turn of the century, to a peak of 82 million tons in 1989.

Aquaculture production in 1994 made up to a total of nearly 25.5 million mt, valued at around US $40 billion. By far the greatest amount is produced in China, whose total aquaculture production is estimated to account for 48% of the total production of all aquacultured products. It is estimated that in 50 years, most of the world's fish supply will come from aquaculture production.

Latin America and Caribbean Aquaculture Production

South America does not have a long tradition of aquatic farming, although in recent years it has grown at a rapid rate. In 1994 FAO (FAO/FIDI 1999) reported that the total aquaculture production in Latin American and the Caribbean was 472, 429 mt, which represented 1.85% of the world production, with a value of US$1,884.74 millions. From 1984 to 1994 this production increased 288% in biomass and 240% in foreign exchange. In 199, aquaculture produced 193,403 mt of fish (41%), 151,914 mt of crustaceans (32%), 65,798 mt of algae (14%), and 61 251 mt of mollusks (13%).

Latin America aquaculture production statistics from 1984 to 1994 indicate that Chile is the main producer of fish (salmon) and Ecuador of shrimp. Mexico is the main producer of cultured mollusks in Latin America, with 48,583 mt, representing 90% of the total for Latin America and the Caribbean.

Mexican Aquaculture Production

Aquaculture is developing in Mexico, but fluctuations in production indicate that the industry is in a period of unstable development. During 1983 - 1989, aquaculture production increased at an average rate of 8.6% annually (122,148 mt in 1983), but in 1994 aquaculture production was 7.03%, less than 1989.

Although aquaculture has acquired importance, providing social and economic benefits, it has not produced the expected returns. There are three million hectares

of inland waters and coastal lagoons adequate for the culture of penaeid shrimp and others species. Environmental diversity affords a variety of aquaculture opportunitiess, producing different kinds of organisms, by many modalities — extensive, semi-intensive and intensive aquaculture.

In the 1930s, aquaculture in Mexico was focused on rural aquaculture and replenishing water reservoirs. Aquaculture efforts were conducted mainly in inland waters, primarily fish culture for stocking and population replenishment. Today there are programs to develop aquaculture, but the lack of support for new aquaculture initiatives persists in most the cases.

Species traditionally reared in Mexico were trout, catfish, american oyster, carp, tilapia, and freshwater crayfish — the last three species are non-indegenous to Mexico. More recently, other aquaculture species have been farmed in the country — peneaid shrimp, bay scallop, lion paw scallop, ornamental fish, marine food fish, abalone, pearl oyster, mussels, and some others. With the exception of shrimp, the remaining species have not shown any significant commercial impact.

Many aquatic species have been cultured on an experimental and/or pilot scale since the early 1970s (Table 1). However, only a few species have reached commercial-scale development, including freshwater fish, american oysters, and shrimp.

Figure 1 compares total fishery catch in mt and aquaculture production during 1997. The main aquaculture species produced included mojarra (47%), american oyster (22%), carp (14%) and shrimp (10%). Only shrimp and a small quantity of oyster were produced through intensive aquaculture. The other 90% of aquaculture production was produced through extensive aquaculture.

Tilapia, american oyster, and carp have a high social impact, their volume represents 79% of the total production, almost exclusively for domestic consumption. Shrimp production has increased an average of 49% annually from 1988 to 1994.

Figure 2 shows aquaculture production in biomass (mt) and value. Shrimp is the most valued commodity, other species are cheaper in the market. Table 2 shows Mexico's aquaculture production by region. Shrimp are produced primarily along the Pacific coast, while mojarra and american oyster are produced in the Gulf of Mexico.

Shrimp rearing has introduced an important number of social and private enterprises, generating new jobs and foreign exchange. Nonetheless, care must be taken to ensure that shrimp farming has minimal affect upon other productive activities and natural resources. Also, the lack of research and development in the shrimp farming sector has restrained the industry's development.

From 1983 to 1995 aquaculture production has had an annual average growth of 2.7%, from 122,148 mt in 1983 to 171,389 mt in 1994.

Table 1. Aquatic species cultured commercially (C) , experimentally (E), pilot (P) culture.

Common name	Scientific name	Culture	Papers	%
FRESH WATER FISH				
Mojarra	*Cichlasoma urophtalmus*	C	5	3.08
Carp	*Cyprinus carpio*	C	5	3.08
	Cyprinus carpio variedad specularis	C		
	Ctenepharyngodon idella	C		
Black Bass	*Micropterus salmonoides*	C	1	0.60
Catfish	*Ichtalurus puntatus*	C	1	1.60
Trout	*Onchorynchus mykiss*	C	2	1.23
Charal	*Chrirostoma spp*	C	-	-
Tilapia	*Oreochromus niloticus*	C	6	3.70
	Oreochromus mozambicus	C		
	Oreochromus aureus	C		
Ornamental fishes			2	1.23
MARINE FISHES				
Grouper	*Epinephelus morio*	E	1	0.60
Snapper	*Lutjanus argetiventris*	E	1	0.60
Other fishes			4	2.50
CRUSTACEANS				
Shrimp	*Penaeus vanamei*	C	47	29.01
	Penaeus californiensis	P		
	Penaeus stylirostris	E		
	Penaeus setiferus	E		
Freshwater prawn	*Macrobranchium rosembergi*	E	1	0.06
	Procambarus clarkii	E		
MOLLUSKS				
American oyster	*Crassostrea virginica*	C	10	6.17
Japanese oyster	*Crassostrea gigas*	C		
Scallops	*Argopecten ventricosus*	P	13	8.02
Mussels	*Mytilus galloprovincialis*	E	3	1.85
	M edulis			
	M. californianus			
Abalone	*Haliotis fulgens,*	P	16	9.87
	H. Rufescens			
Queen conch	*Strombus gigas*	E	9	5.55
	S costatus			
	S. pugilis			
FROGS	*Rana toro*		3	1.85
MICROALGAE			6	3.70
MACROALGAE	*Gracilaria spp*	E	5	3.08
ZOOPLANCTON	*Artemia naupli, A. Franciscana, A.*	E	10	6.17
	Spp, Brachiorus plicatilis			
OTHERS	0.66		12	7.41

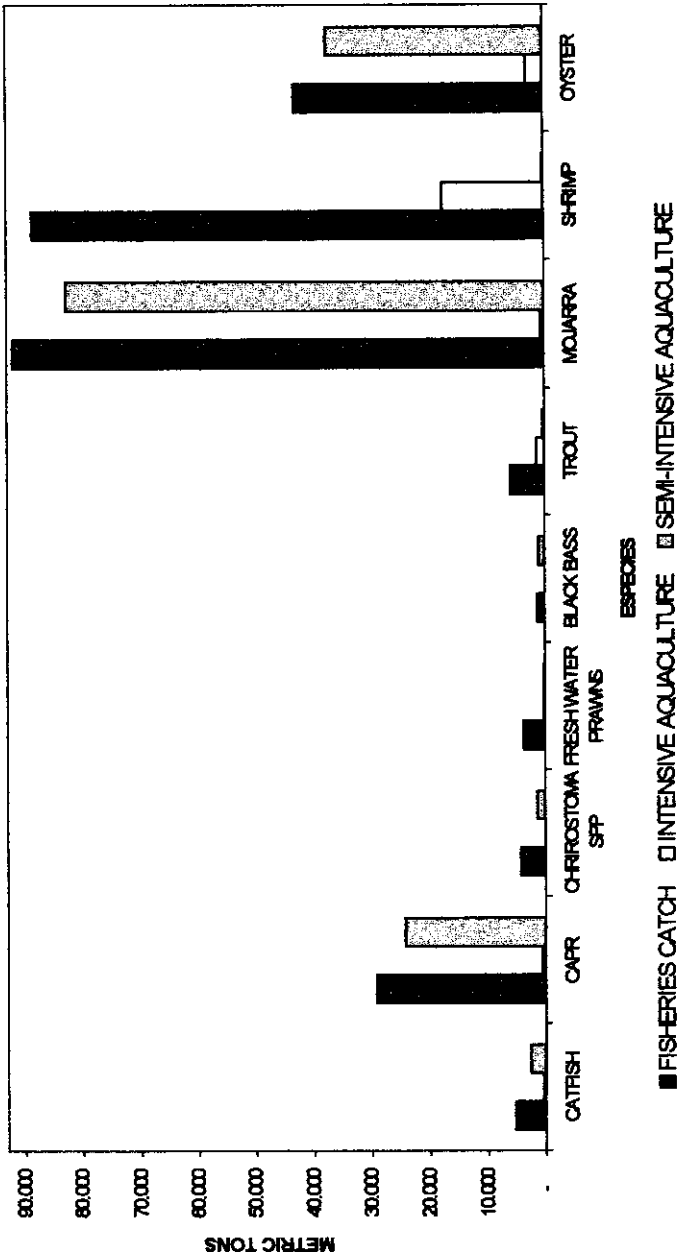


Figure 1. Mexican aquaculture production and fisheries catch for different species (1997).

Table 2. Mexican aquaculture production (mt) by categories of species in different States (Quantities in mt).

	Total	Mojarra	Shrimp	Oyster	Carp	Catfish	Trout	Chrirostoma spp.	Black Bass	Freshwater Prawns
TOTAL	**173,878**	**83,132**	**17,570**	**40,381**	**24,848**	**2,816**	**1,512**	**1,330**	**1,006**	**130**
Pacific	57,660	30,193	16,856	2,910	4,764	1,064	210	742	578	98
B. California N	1447	-	-	1,230	-	-	-	-	-	-
B. California S	116	-	43	73	-	-	-	-	-	-
Sonora	7,527	757	4,688	1,243	234	483	-	-	121	-
Sinaloa	13,734	2,793	10,215	5	-	503	-	-	218	-
Michoacán	15,882	12,623	-	-	2,885	2	110	-	234	1
Chiapas	5,794	5,050	500	-	232	-	12	-	-	-
Gulf of México and Caribe	80,405	41,020	714	37,471	-	913	135	-	59	-
Veracruz	38,048	23,620	8	14,285	-	-	135	-	-	-
Tabasco	32,087	14,045	149	17,893	-	-	-	-	-	-
Yucatán	283	3	277	-	-	-	-	-	-	-
Inland waters	35,815	11,920	-	-	20,085	838	1,168	589	368	32
México	4,463	435	-	-	3,376	5	359	218	22	7
Nuevo León	153	45	-	-	46	61	-	-	-	-

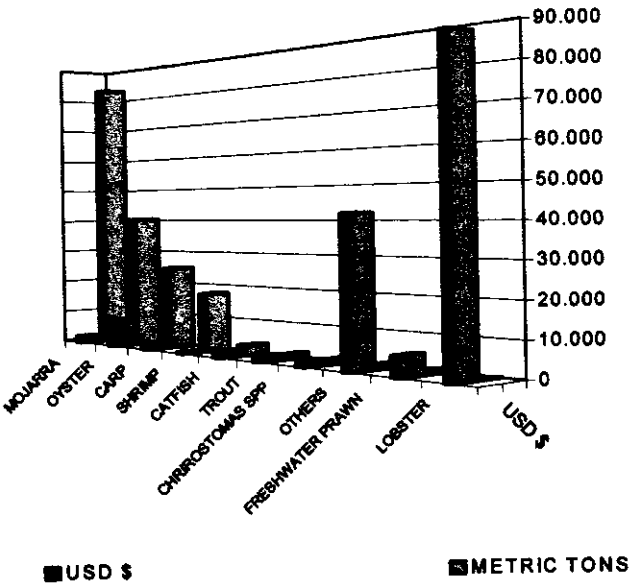


Figure 2. Mexican aquaculture production, volume, and value (1997)

Although production of some species has fallen, during the years1983 to 1994 tilapia production inceased by 3.1% annually, from 58,000 to 7, 000 mt. Carp production increased by 8.8%, from 7,000 to 19,000 mt. Aquaculture production of trout and catfish showed growth increments of 17.9% and 5.5%, respectively. Oyster production reached a maximum of 57,000 mt in 1989, however, this production decreased to 33,000 mt in 1995. These decreases have been related to water quality and diseases.

Aquaculture of charal (*Chrirostoma spp.*) shows an average decline per year of 9.1% from 1987 to 1994. The production of Black-bass had a reduction of 1.2% per year in the same period.

An analysis of the aquaculture official programs in 20 years (1980-1989), shows the lack of adequate techniques, human and economics resources to achieve the goal of these programs. The objectives from 1988 to 1994 were not reached, due to problems in public administration. The hatcheries and nurseries were eventually without support.

In these 20 years, aquaculture has introduced new species, of high commercial value, like shrimp. In 1987 were obtained 286 mt and in 1994 13 138 mt.

For the development aquaculture is necessary to solve the met subjects: diseases, reproductive biology, and nutrition among the most critical, to know the patters reproductive cycle for natives species and their nutritional requirements. Another problem is the poor infrastructure of Mexican hatcheries, which can not produce the spats or juveniles required for further expansion.

IDENTIFICATION FOR ESTABLISHING RESEARCH COOPERATIVE PROJECTS

Mexican Institutions of Marine Sciences

Mexico has 79 academic institutions, 19 of which offer programs in Biology or Marine Science and 11 related to Fisheries and Aquaculture (Table 3). Thirty schools offer a bachelors degree in Biology, and 49 a bachelors degree in topics related to marine science. Three of the main fishing regions of Mexico (Tamaulipas, Yucatán and Quintana Roo) do not offer a bachelors degree on marine science topics. Sixty one percent of the acadmeic institutions that offer courses in marine science are located on the Pacific coast, 24% on the Gulf of Mexico coast, and 15% in Mexico City; none on the Caribbean. These schools have 9,550 students, of which only 793 (8.3%)graduated, 78% studied for a degree in biological science, 7.4% in marine science, 2.3% in fisheries, and 0.05% in ecology.

Table 3. Bachelor degrees in natural science, biology or marine science related: Oceanography, fisheries and aquaculture offered in Mexico.

Area	Carreer	Schools
Natural Science	Biology	30
	Fisheries biology	3
	Marine biology	3
	Experimental biology	2
	Systematic biology	1
	Ecology biologist	6
	Aquaculture biologist	3
	Agriculture biologist	1
	Hydrobiology	1
Oceanology	Chemical oceanography	1
	Oceanology	1
Ecology	Marine ecology	1
Engineer	Naval engineer	4
	Oceanology engineer	1
Fisheries and Aquaculture	Aquaculture engineer	6
	Fisheries engineer	9
	Marine food technology engineer	3
	Fishing technology engineer	2
	Aquatic resources engineer	1
Total		**79**

Mexican Institutions with Graduate Studies in Marine Sciences

Table 4 shows the different graduate studies programs in Marine Science in Mexico, year it started, Institution that offers it, degree offered. The board of professors increased 62% from 1989 to 1994, even though the percentage of graduated students has been low. During 1989 there was 0.16 new PhD. by year going up to 0.36 PhD in 1995.(Aldana Aranda 1997).

The mean duration of these graduate studies programs is 13.7 years. So, Mexico has only ten years of production of graduate students in marine science.

Most mexican scientists have graduated abroad. Only 25% of the coastal states have graduate studies in marine science, 64% on the Pacific coast, 5% on the Gulf coast, and 32% in Mexico city. During 1995, 124 students graduated with a Master of Science on marine science and 8 for a PhD.

Table 4. Graduate studies programs in Marine Science in Mexico. (M) Master of Science, (D) PhD and (E) Speciality.

Program	Institution	Year it started	Certified
1.Biology : Sistematic of Marine	CICESE	1978	E
invertebrates	CICESE	1978	E
2. Marine Pollution	CICESE	1978	E
3. Benthos Ecology	CICESE	1978	E
4. Larvae and fishes Ecology	CICESE	1978	E
5. Plankton Ecology			
6. Marine Ecology	CICESE	1978	M, D
7. Phisic Oceanography	CICESE and ICMyL	1978	M, D
8. Management of Marine resources	UABC	1980	E
9. Coastal Oceanography	UABC	1980	M, D
10. Biology Oceanography	UABC	1980	M
11.Marine Sciences	CICIMAR, ITESM	1978	M
12. Fishery Ssciences	CICIMAR	1978	M
13. Management of Marine resources	CICIMAR	1993	M
14. Management of Coastal Natural Resources	CIBNOR	1995	D
15. Management of Natural Resources	UABCS	1993	M
	U.Sinaloa		M
	U.Oaxaca	1996	M
	U.Yucatán	1990	M
16. Aquaculture	UABCS	1993	
	U.Campeche	1996	
	U. Manzanillo ITESM	1993	
17. Ecology	E.N.C.B IPN	1961	M, D
18. Biology and Fishery Oceanography	ICMyL UNAM	1970	M, D
19. Chemistry Oceanography	ICMyL UNAM	1970	M, D
20. Geology Oceanography	ICMyL UNAM	1970	M, D
21. Biologic Sciences of aquatics systems and resources	UNAM F. Ciencias		M, D
22. Ecology and Environmental Sciences	UNAM, F.Ciencias		M, D
23. Biology	UNAM, F.Ciencias		M, D
24. Zoology	UNAM, F.Ciencias		M, D
25. Aquatic Ecology y pesca	UNAM, F.Ciencias		M, D
26. Ictiology	UNAM, F.Ciencias		M, D
27. Aquaculture and Fishery	UNAM, F.Ciencias		M, D
28. Ecology, Aquaculture and Fishery	U. Nuevo león		M
29. Aquaculture Production	U. Nuevo León		M
30. Fishery Sciences	U. Sinaloa		M
31. Marine Sciences	CINVESTAV IPN	1982	D
	CICIMAR	1978	M
32. Marine Biology	CINVESTAV IPN	1980	M

Mexico's Budget for Research in Marine Science

From 1991 to 1995 the Mexican Institution for the development of Science CONACYT approved 2,278 research projects providing US$ 279,045,992. Only 51 projects were related to marine science, accounting for 4.38% of the total budget for five years. During 1991 - 1995 this budget increased from 0.64% (1991) to 2.43% (1995). However, the budget is limited to studies of aquatic species for aquaculture.

Mexican Scientist Within the National Scientist Program

The National Scientist Program (SNI) had 5 871 registered members for the year 1995, 56% working at Mexico city, and 44% in the United States, but only 57 worked on a marine science topic (Table 5).

Table 5. Number of scientists from SNI with their specialty in marine science and the percentage of the total number of scientists in the biological sciences

Specialty	Number of Scientists	Percentage (%)
Marine Biology	22	2.75
Marine Ecology	15	1.88
Aquaculture	5	0.63
Marine Botany	5	0.63
Ichthyology	4	0.50
Malacology	3	0.38
Carcinology	1	0.13
Marine Physiology	1	0.13
Marine Microbiology	1	0.13
Total	**57**	**7.16**

Figure 3 shows the papers (indexed in Science Citation Index) produced during 1986 - 1999 by Mexican Institutions. Mexico has 21 different Institutions that have produced at least one manuscript related to aquaculture. CIBNOR has produced the most papers in aquaculture with 28 published (Table 4). UNAM produced 22 manuscripts, followed by the University of Baja California with 15 and CINVESTAV and CIAD with 13 each.

Figure 4 illustrates the species studied in different mexican institutions during 1986 -1999. Mexican institutions have been working with 60 different aquatics species and they have produced 162 scientific manuscripts indexed. These results show few studies for every one species. So, UNAM studied 14 species. University of Baja California and CIBNOR are working with 12 and 11 different species respectively. Finally, CICESE, CINVESTAV and UAM are working with 6 or 8 different species.

Nutrition has 32 papers realised by 12 different centers. Aquaculture techniques has 27 papers realised in 16 different Institution. Growth has been studied by 12 institutions, which have been produced 25 scientific manuscripts. Topics like Biochemistry has 14 studies produced by 9 Institutions. Physiology 9 papers by 6 Institutions, Marine Pollution 8 papers in 6 Institutions. Finally, Pathology has 10 papers produed by 8 institutions. So, Mexico does not have an institution specialised in only one topic of Aquaculture. The question to know is: ¿what is better for developing aquaculture, to have institutions with any specific topic, or to have research centers with many specialists?

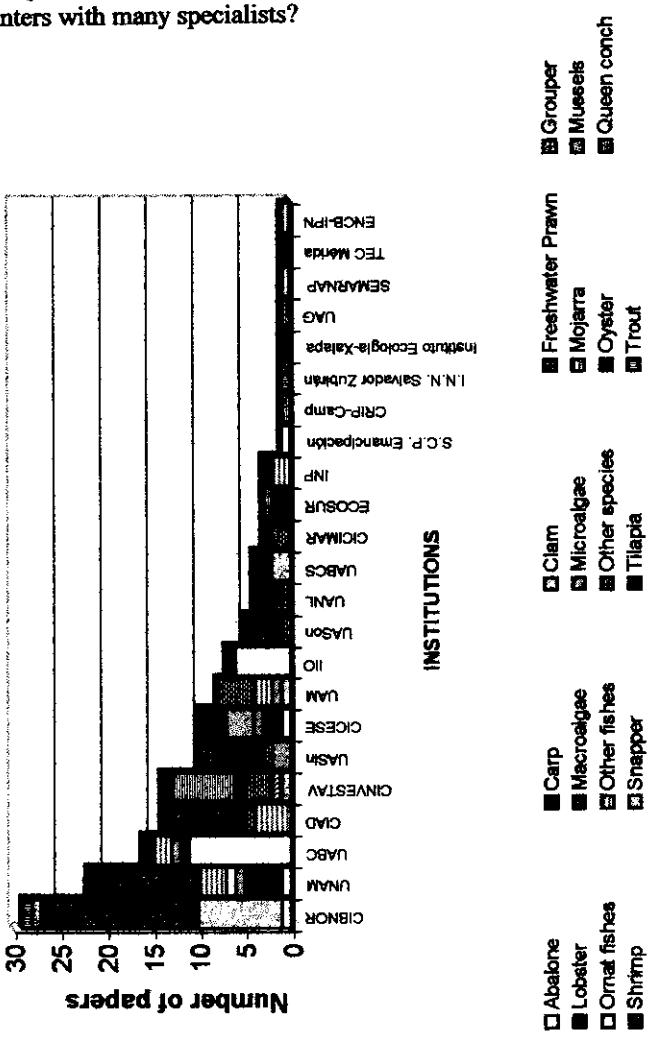
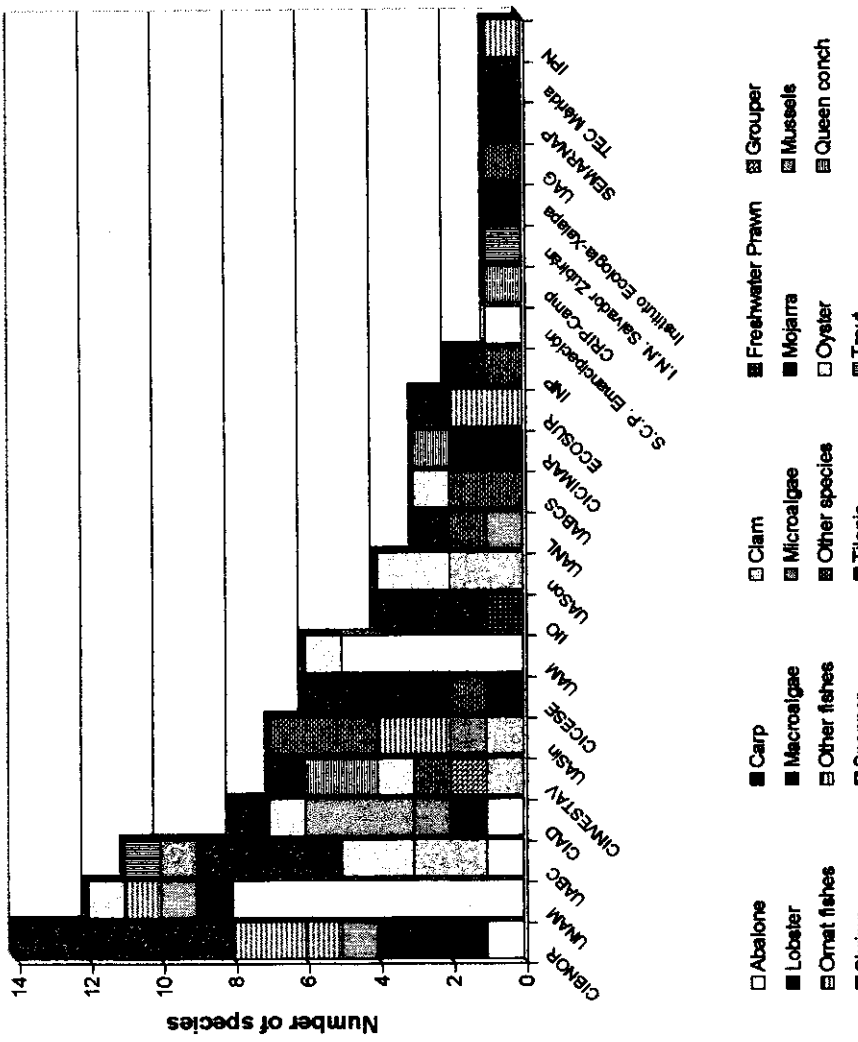


Figura 3. Number of papers produced by different mexican institutions (1986 - 1999).



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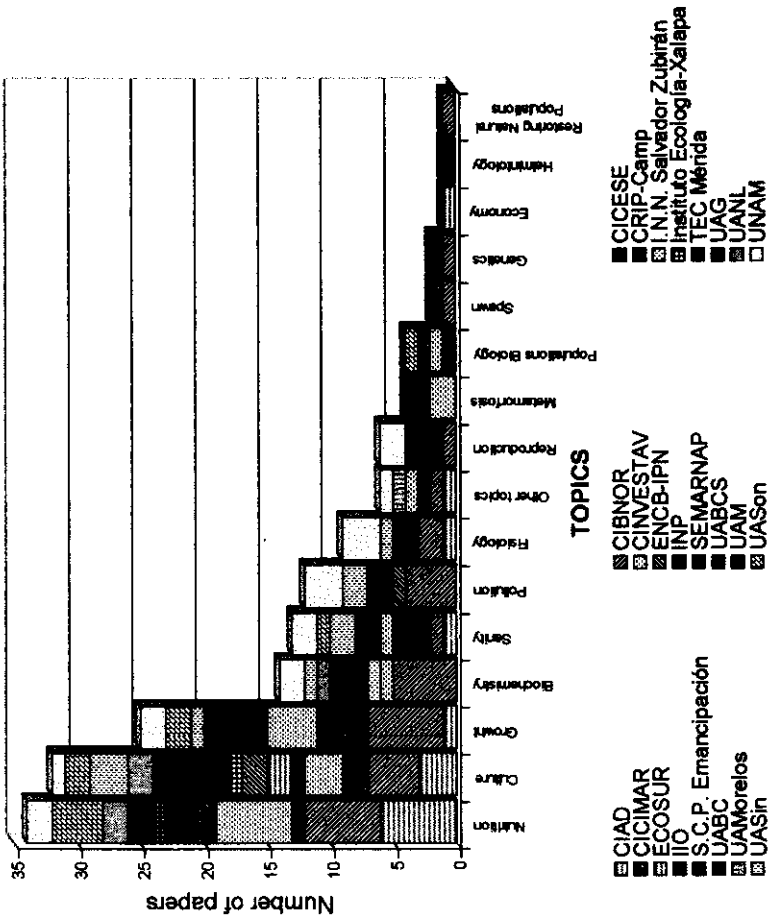

Figura 5. Number of papers realized by different mexican institutions on different topics (1986 -1999).

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