Aquaculture in Costa Rica

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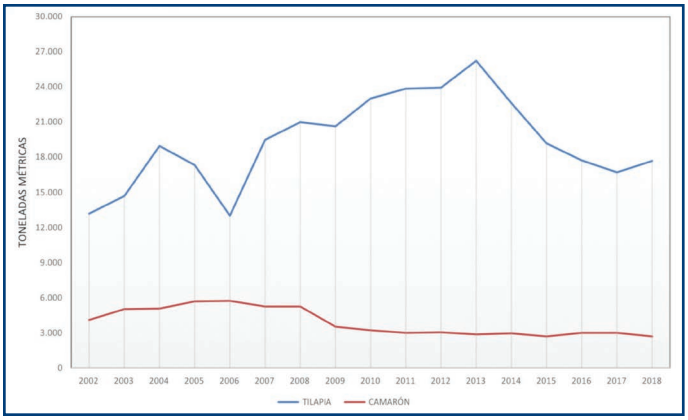

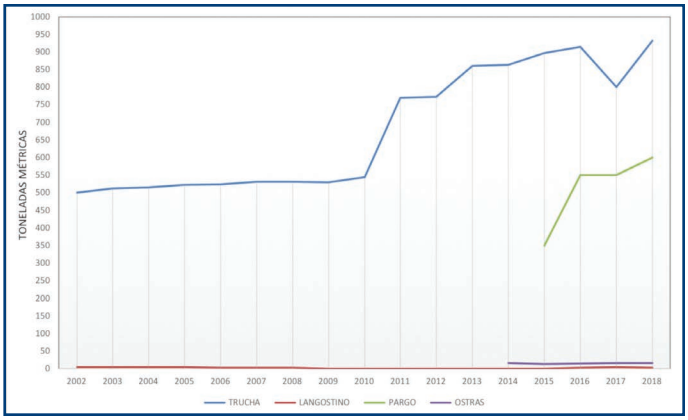

LEFT, FIGURE 1. *Annual production of the two main aquaculture crops in Costa Rica from 2002 to 2018. Source: INCOPESCA, personal communication, 2019.*
RIGHT, FIGURE 2. *Annual production of emerging species in Costa Rica between 2002 and 2018. Source: INCOPESCA, personal communication, 2019.*

Background

Costa Rica may be a small country in land area (51,000 km^2) but it has abundant freshwater resources from its mountain ranges, a tropical climate, and a marine exclusive economic zone of almost 600,000 km^2 that make the country suitable for aquaculture development. Freshwater aquaculture began in the 1960s with the objective of promoting socio-economic development in rural areas by adopting technologies to produce introduced tilapia species *Oreochromis mossambicus* and *Sarotherodon melanopleura* (FAO 2016). In the decades that followed, experimental culture of rainbow trout *Oncorhynchus mykiss* and freshwater prawn *Macrobrachium rosenbergii* was conducted (Galvez and Guenther 1987). Marine aquaculture began in the 1970s with the cultivation of the shrimps *Litopenaeus vannamei*, *L. stylirostris* and *L. occidentales* (FAO 2016, Nanne 1986). In the 1990s, seed production and the culture of the Pacific oyster *Crassostrea gigas* and the first investigations with spotted rose snapper *Lutjanus guttatus* were initiated (Arias *et al*. 1998, Gutiérrez-Vargas and Durán-Delgado 1999).

National Production and Consumption

According to the Costa Rican Institute of Fisheries and Aquaculture (INCOPESCA), national aquaculture production by species in 2018 was 80 percent tilapia (16,667 t), 13 percent marine shrimp (2,689 t), 4 percent rainbow trout (827 t), and 3 percent snapper (600 t) (Figs. 1 and 2; INCOPESCA 2019). The production of oysters and freshwater prawns occurs, but only at a small scale, generating around 16.5 and 4 t, respectively (INCOPESCA 2019). About 76 percent of total tilapia production corresponds to production by Acuacorporación Internacional S.A., located near Cañas, Guanacaste Province.

Between 2013 and 2017 tilapia production decreased in response to the increase in imports of fish (tilapia and pangasius catfish) from Asia. However, during 2018, production increased by almost 1,000 t in relation to 2017 as a result of an increase in exports.

With respect to shrimp farming, production declined by about 50 percent between 2009 and 2015, associated with the presence of diseases, the low level of technification of producers, environmental policies, local trade and the competition of national product abroad. Shrimp produced in Costa Rica has managed to position itself in the European market as a certified organic product, leading to a gradual increase in production.

Rainbow trout, freshwater prawn, snapper and oysters have diversified aquaculture production in Costa Rica (Fig. 2). Trout production has increased from less than 550 t in 2010 to 932 t in 2018. Exports of this premium product have been vital for the development of this aquaculture sector. Another product with great potential has been snapper, which has shown an accelerated production, increasing from 350 t in 2015 to 600 t by 2018.

Freshwater prawn has been produced on a small scale for local or family consumption since 2002. Until 2018 there has been no exponential development of the species, although the interest is maintained and the environmental conditions of the country are optimal for its cultivation. Since 2014, oyster production has been maintained without exceeding 16 t/yr but its potential is widely known and it is expected for the next few years that the number of farms dedicated to oyster aquaculture will double or triple.

There are 287 aquaculture producers in Costa Rica, generating around 2,005 direct jobs, 69 percent of these in tilapia farming. In addition, fishing and aquaculture contribute 0.10 percent of GDP, 7.1 percent of the national livestock production and an average of 1.6 percent of the country's exports (Beltran 2014, FAO 2016).

National fish consumption per capita is 10.4 kg/yr, but most of the national aquaculture production in 2018 was exported to the USA and Europe; therefore, it is necessary to import fish (tilapia and pangasius) to cover domestic demand. This deficit presents opportunities for new investments in the national aquaculture sector.

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FIGURE 3. *Blue tilapia* Oreochromis aureus.

FIGURE 4. *The commercial tilapia farm operated by Acuacorporacíon Internacional near Cañas uses irrigation system water from Lake Arenal.*

FIGURE 5. *Aeration of intensive flow-through tilapia ponds operated by ACI.*

FIGURE 6. *Rainbow trout fry ready for marketing to producers.*

Main Freshwater Species

Tilapia

Tilapia is one of the most important aquaculture species in the country, with industrial, médium- and small-scale producers (Sánchez and Cambronero 2016). Among the species used in Costa Rica are blue tilapia *Oreochromis aureus* (Fig. 3) and Nile tilapia *Oreochromis niloticus*. It is marketed as whole fish, fresh and thawed fillets or in pancitas. Fillets can reach 20 cm and weigh approximately 150 g, while whole fish is marketed from 500-600 g (Sánchez and Cambronero 2016). In recent years, tilapia consumption has increased and the product can be found in fish markets, supermarkets, fairs, restaurants and in recreational fishing ponds.

The ACI Group is the largest company in the country that is dedicated to the production, processing and marketing of tilapia (Fig. 4). It is owned by Aquacorporación Internacional and has around 600 ha of intensive production ponds (Fig. 5) and the Terrapez processing plant that produces fresh fillets and other derivatives.

Rainbow Trout

The introduction of rainbow trout to Costa Rica occurred in 1927, with significant production occurring since 1968. The Ministry of Agriculture and Livestock promoted the creation of the research and production center Truchícola Ojo de Agua de Dota to supply seed (Fig. 6) and promote development of the activity (Alvarado 2002). At present all fingerling production is derived from imported eggs (INCOPESCA 2019). In intensive cultivation of rainbow trout, all phases of production are developed, starting with extraction and collection of eggs and sperm, fertilization, incubation, nursery, all stages of development and fattening (Vargas 2003).

A market approach that has boosted development of trout farming has been direct sale to the public, where people visit farms and catch trout directly. Trout are presented in several forms that are used for national consumption and exports, including whole, split whole, fillet without packing and vacuum packed, smoked whole and smoked fillet vacuum packed (Alvarado 2002). The largest trout producer in Central America is Truchas Reales de Costa Rica S.A., with more than 25 years of experience and a processing plant. Their trout products have national and international quality certifications.

Freshwater Prawn

The cultivation of freshwater prawn (Fig. 7) is done at a small scale and small production systems are distributed throughout the country, with the northern and southern areas being the main production areas. Currently, two hatcheries are responsible for supplying all national producers with seed. Some studies have indicated the aquaculture potential of endemic freshwater prawn species *M. panamense*, *M. americanum* and *M. tenellum* (Gutiérrez 2009).

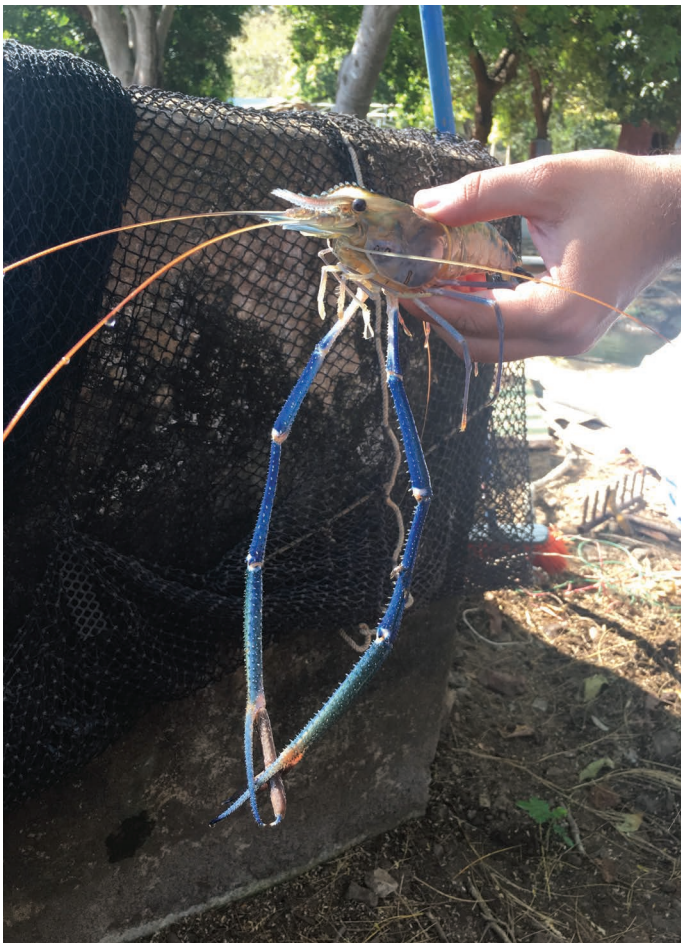

FIGURE 7. *Freshwater prawn* Macrobrachium rosenbergii *broodstock.*

FIGURE 8. *Pangasius catfish broodstock.*

FIGURE 9. *Marine shrimp cultured in semi-intensive systems.*

FIGURE 10. *Spotted rose snapper* Lutjanus guttatus.

Other Species

Commercial trials have been carried out with Australian redclaw crayfish *Cherax quadricarinatus* and channel catfish *Ictalurus punctatus*, although these were limited and more research and marketing is required. Costa Rica now allows production of pangasius catfish and has imported broodfish from Asia (Fig. 8). The country has favorable conditions for its commercial development and a very high-quality product could be offered to the local and international market. Pangasius reach an adult age in three years, with weights of 2.5-3.5 kg for males and 3-5 kg for females (Til-Gen 2015).

Main Marine Species

Penaeid Shrimp

The current production of shrimp is based on Pacific white shrimp *Litopenaeus vannamei* (Fig. 9). Growth of the sector since the 1990s has been limited by definition of mangrove areas as wetlands protected by the Ramsar Convention (Gumy *et al*. 2014). In addition to this constraint, shrimp production is limited by several disease problems and the low level of producer technification (Peña and Varela 2016). Semi-intensive crops prevail, where stocking densities of 10/m^2 are normally used in three short cycles of 90-120

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FIGURE 11. *Spotted rose snapper are grown in 5,500 m³ net pens operated by Industrias Martec S.A near Quepos.*

days, with harvest weights around 11-14 g. Shrimp production can vary between 600 and 1200 kg/ha per cycle. Shrimp larvae are imported from Nicaragua, Guatemala, Honduras or Ecuador. Organic shrimp are produced for export and conventional shrimp are generally produced for local consumption. Currently, pilot-scale shrimp farms are being started in floating cages, especially for sale as bait in responsible fishing areas and the implementation of intensive crops in small and highly technified systems (biofloc) is also being initiated.

Snapper

There is a strong export market in the US with attractive prices for fresh spotted rose snapper (Fig. 10). The base technology of mass production of juveniles in Costa Rica was developed in 2002 by the Marine Park of the Pacific (PMP) with support of the national university and other state institutions (Chacón-Guzmán 2010, Herrera-Ulloa *et al*. 2010, Carvajal-Oses *et al*. 2018). Between 2005 and 2006, PMP produced the first 45,000 juveniles that allowed implementation of the first commercial cage farm managed by low-income fishermen in the Gulf of Nicoya. In 2011, they implemented a new integrated farming project with tourist activities to diversify income and achieve a project structure that generates positive profitability (Chacón-Guzmán *et al*. 2018).

In 2008 the PMP and the private company Industrias Martec S.A. established a technology transfer agreement. The PMP produced 70,000 juveniles for the company and with this, the first exports with industrial characteristics were achieved in 2009. Currently, Industrias Martec S.A. has a hatchery (almost 2.4 million juveniles in 2017) and a 15-km² concession near Quepos for the development of an industrial snapper farm using net pens (Fig. 11). The company's goal is to increase production to around 5,000 t/yr.

In addition, the PMP has released about 250,000 snapper juveniles for conservation and environmental education purposes in wildlife refuges and other coastal areas, integrating school groups, parents, fishermen and the general public in the activities as a strategy to sensitize and protect coastal marine resources and to highlight the beneficial environmental services provided by aquaculture (Chacón-Guzmán *et al*. nd)

Oysters

Oyster producers in Costa Rica operate at an artisanal level (Fig. 12) but are in the process of improving production techniques

FIGURE 12. *Artisanal cultivation of oysters using lantern nets on longlines in the Gulf of Nicoya.*

(FAO 2016). Farms receive seed of a size greater than 2.5 mm and long-lines of 100 m are used. Normally, the stocking density is 50 oysters per lantern and harvest is expected eight months later with commercial sizes between 6 and 8 cm. The biggest problem faced by oyster farmers has been the shortage of seed but the national university has built a hatchery with a production capacity of 1.5-2.0 million seed per month. It is expected that this hatchery will start continuous production in the second semester of 2019 and thereby improve the productivity of existing and new projects, projected to be 14 farms in the next years.

Other Species

Initial investigations that defined reproductive aspects, larval culture and growth of corvina *Cynoscion squamipinnis* and *C. albus* and berrugate (Pacific tripletail) *Lobotes pacificus* (Fig. 13) have been carried out (Boza *et al*. 2017, Chacón-Guzmán *et al*. 2015). However, consistent and quality reproduction is still required, which would allows scale-up of production to massive levels and thus allowing further definition of nutritional, microbiological, genetic and management aspects in general. Then it would be possible to assume the acquisition of a base production technology.

Strategies to Increase the Production and Competitiveness of Aquaculture

The national government has been making efforts through the Instituto Costaricense de Pesca y Aquicultura (INCOPESCA), which has the mission of promoting the development of the fisheries sector, mariculture and continental aquaculture of the nation under the principles of sustainability. In collaboration with the FAO, INCOPESCA presented an analysis of the current situation of the aquaculture sector in Costa Rica (FAO 2016), a diagnostic study that has provided basic information for establishment of the main priorities for aquaculture development. In 2019, INCOPESCA developed a Strategic Plan for Aquaculture in Costa Rica that aims to guide the management, strengthening and development of aquaculture activity in the country (INCOPESCA and SEPSA 2019).

FIGURE 13. *Berrugate (Pacific tripletail)* Lobotes pacificus *broodfish.*

Training of Human Resources and Research

In Costa Rica, the Universidad Nacional de Costa Rica (UNA) and the Universidad Técnica Nacional (UTN) stand out for orienting their efforts towards training and development of human resources. The UNA has made contributions to this sector since the 1980s and has trained professionals in marine and freshwater biology, as well as graduates in aquaculture. Its School of Biological Sciences has research laboratories on biotechnology, genomics, histology, freshwater aquaculture, marine shrimp reproductive biology and water quality, among others, which has resulted in the generation of varied knowledge related to aquaculture (Alfaro-Montoya *et al*. 2017; Jiménez-Montealegre *et al*. 2016, Ulloa 1997, Valverde-Chavarría *et al*. 2016).

In Puntarenas Province, the UNA has two stations, the Marine Biology Station (EBM), where research is carried out on reproduction and larval culture of marine fish and oyster production (Alfaro *et al*. 2017) and the Marine Science Station (ECMAR), located in Punta Morales, where the new laboratory for the mass production of oyster seed is located. The integrated rural development program of the Gulf of Nicoya, which offers support for the development and strengthening of organizations related to fisheries and aquaculture, is also based at ECMAR (Pacheco-Urpí and Ulate-Garita 2016). In addition, the UNA is a founding partner of the Parque Marino del Pacífico, an institution that contributes to the generation of productive alternatives for the Pacific coast of Costa Rica (Herrera-Ulloa *et al*. 2009).

Since its creation in 2008, the UTN has been developing research and extension programs for improvement of aquaculture production and development of social enterprises that promote community growth in the country. There is also an experimental aquaculture farm of more than 5 ha dedicated to the production of tilapia seed and research on catfish, pangasius and freshwater prawn. It has an aquaculture pathology laboratory that provides disease diagnostic support to the production sector. The main investigations are related to the diagnosis and control of diseases, the search for alternatives that improve the shrimp production sector, genetics of species and quality of broodstock of commercial species. In addition, UTN has promoted implementation of social programs and offers a degree program in aquaculture engineering, with the objective of training professionals in the aquaculture sector.

Others state universities that have made efforts to develop the country's aquaculture sector are the Universidad Estatal a Distancia (UNED), which is currently developing a pilot mussel farming project with fishing communities in the Gulf of Nicoya (Jiron-Fajardo and Chan-Castillo 2016), and the Universidad de Costa Rica (UCR), which has made contributions to aquaculture through several investigations on different topics (Vargas-Cordero and Quirós-Arias 2016, Radulovich 2006).

INCOPESCA has an aquaculture department and two juvenile production stations. The Los Diamantes aquaculture station is located in Guapiles, in Limón Province in the Caribbean area, specializing in production of tilapia fingerlings. The Truchícola Ojo de Agua station is located in Dota, San José Province, in the central volcanic mountain range, and specializes in production of rainbow trout fry. In addition, it has qualified professional staff and its main priority is development of this activity through long- and medium-term work programs that support annual operational plans.

Another state agency that provides human resources to the sector is the Instituto Nacional de Aprendizaje (INA), which conducts technical training, arranges apprenticeships, and gives organizational and business support to producers through its small- and medium-size enterprises program.

Outlook for Aquaculture in Costa Rica

Traditional aquaculture in Costa Rica, especially tilapia and shrimp farming, has remained stable and it is expected that production levels of these key species in the coming years will be similar to those of the present. Also, it is expected that emerging species such as marine finfish, oysters and pangasius catfish will contribute to increased aquaculture production. Artisanal fishing has weakened in recent years, which is why the oyster industry, together with the small-scale marine fish farming sector, play a strategic role that should be promoted as it can benefit many families that are economically and socially marginalized (FAO 2016).

There is interest by universities to develop aquaculture production technology, generate new information and create research networks that promote knowledge production. The creation of new academic training programs in aquaculture and the need to develop productive alternatives to reduce levels of unemployment and poverty in rural areas will encourage the expansion of aquaculture. In addition, national policies are expected to support development of this sector and favor the generation of new projects and the introduction of foreign capital.

Notes

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