

## Sea cage finfish aquaculture for Pacific Island countries and territories

### Worldwide expansion

The farming of marine finfish species has expanded greatly worldwide since the 1970s. A main constraint has been the supply of fingerlings, but the supply of hatchery-reared fingerlings, from both intensive technological efforts and simpler grassroots methods, has advanced and driven production in what is often a very profitable (and risky) undertaking.

Sea cage aquaculture of temperate and subtropical species such as Atlantic salmon (*Salmo salar*), sea bream (*Sparus aurata*) and sea bass (*Dicentrarchus labrax*) in the Mediterranean produced around 3 million tonnes (t) worldwide in 2020. Tropical marine finfish species such as milkfish (*Chanos chanos*) and barramundi (*Lates calcarifer*) produced 0.5 million tonnes in the same year.

Most of the salmon production comes from complex, vertically integrated companies investing in fingerling supply and industrial sea cage farming, with large boats and advanced technology. Marine farms that specialise in tropical species often involve smaller operators in complex value chains. A dominant constraint for both approaches is the supply of fish feed. Plastic cages made from polyethylene pipe are now common in many areas because they are light, durable, able to withstand heavy weather (if moored correctly), and can be assembled at remote sites. The cost of these materials has

come down considerably as previously innovative manufacturing techniques have become commonplace.

Increasingly though, sea cage farming sites are becoming harder to find in many locations around the world. Conflicts with coastal residents and recreational users, and increased public scrutiny of environmental impacts of marine farms, all reduce the availability of appropriate sites. Appropriate sites are what many Pacific Island countries and territories have in abundance, but sea cage farming of hatchery-produced marine finfish is only occurring in a few locations in the region.

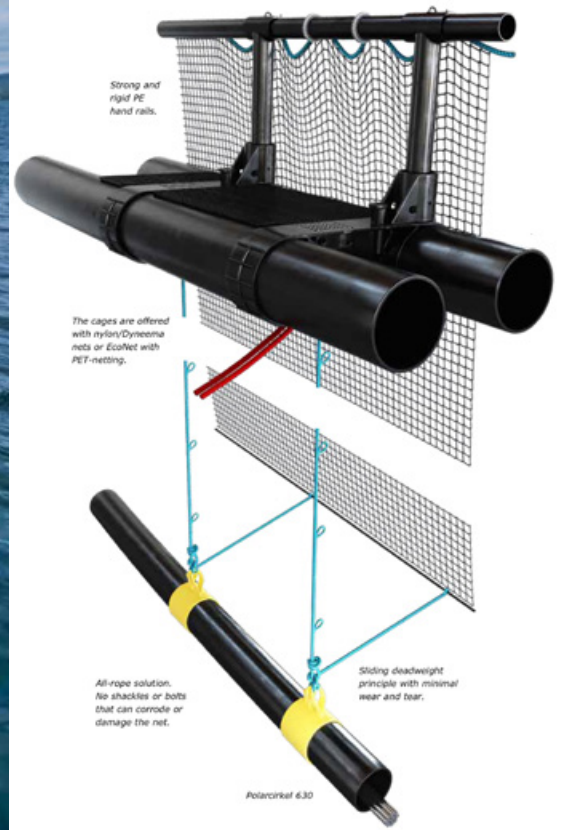
### Pacific efforts

Pond culture of marine species, wild caught as fry, has had a long history in many Pacific Islands. Hawaii has milkfish ponds that were constructed several centuries ago, and Cook Islands, Fiji, Kiribati, Kosrae, Nauru, Tuvalu and Yap all have histories of stocking naturally occurring ponds with milkfish or other marine species for use when sea and weather conditions prevent fishing.

Milkfish is an excellent species for tropical finfish aquaculture because their nutritional requirements are low, they have a wide distribution, and a wide range of environmental tolerances. There has been a 60% increase worldwide in milkfish production from 2008 to 2018; the majority from

Rabbitfish grown in sea cages, Touho, New Caledonia. (image: ©Matthieu Juncker)





Example of a round plastic sea cage and its cross section manufactured by AKVA Group. (source: <https://www.akvagroup.com/pen-based-aquaculture/pens-nets/plastic-pens>)

Indonesia and the Philippines and the majority from sea cage farming. Coastal ponds were previously used in both countries, but productivity was not as high, and required increased utilisation of coastal land resources, which resulted in reduced water quality through pollution or development of agriculture or housing.

Extensive pond methods used in some Pacific Island countries and territories, notably Kiribati, are also trending toward more intensive cage farming based on the hatchery supply of fingerlings. With support from Taiwan and China, Kiribati has a milkfish hatchery facility capable of producing 2 million fry per year from just 200 broodstock, and is moving towards intensive cage farming.

Marine finfish hatcheries are also operating in French Polynesia, the Marshall Islands and New Caledonia. New Caledonia's ADECAL<sup>1</sup> is producing red emperorfish (*Lutjanus sebae*), locally called pouatte, and two species of rabbitfish (*Siganus* sp.) or picot. The development effort in French Polynesia involves the hatchery production and cage rearing of orbicular batfish (*Platax orbicularis*), or paraha peue, for the domestic market, and 60 t or more could support economic production. The Marshall Islands has achieved hatchery production of Pacific threadfin (*Polydactylus sexfilis*), a fish of high value in Hawaii where they are called moi.

## Hatchery production of fingerlings

A marine finfish hatchery is a complicated operation, and needs to be supported by trained staff, specialised equipment and feed. Water quality must be maintained at high levels and temperature kept as stable as possible. Live feed of different types must be produced, and broodstock often held for long periods of time before they are in a reproductive condition to be successfully manipulated to spawn.

Two broad strategies are used in relation to the application of technology. The extensive approach principally lacks a high degree of temperature regulation for conditioning broodstock, and feeds larval fish with “greenwater” cultures of mixed, naturally occurring microalgae and zooplankton. This method forms the strategy for milkfish fingerling production in Kiribati and underpins the industry in Southeast Asia.

A more expensive and intensive approach involves the operation of indoor recirculating aquaculture systems with controlled temperature and lighting. This approach is used in New Caledonia. The increased investment allows for more frequent maturation of broodstock by establishing broodstock groups subjected to different artificial seasons and thus an increased production of eggs at a time to suit

<sup>1</sup> Agence de Développement Économique de la Nouvelle-Calédonie (New Caledonia Economic Development Agency)

planned production. Finfish larvae in this type of operation are fed from monocultures of intensively reared zooplankton (principally rotifers and brine shrimp), enriched by feeding the zooplankton with intensively cultured microalgae containing fatty acids important to larval development (n-3 fatty acids EPA/DHA). Copepods are also used for live feed, although they are hard to culture but can be used to feed larvae with smaller mouths.

Good larval nutrition early in the fish's life is crucial in both extensive and intensive approaches; it aids in swim bladder development and inflation, which is an important energy stage for larval marine finfish that need adequate energy reserves to avoid significant larval mortality. From the hatchery, the use of land-based nursery systems for small fingerlings can increase survival rates after transfer to sea cages. Land-based nursery systems (overwhelmingly in recirculating aquaculture systems) are becoming increasingly important for many marine finfish producers who are rearing bigger fish because the risks of predation, disease and weather are reduced. The bigger the fish when placed in sea cages, the closer they are to harvest size so there is less time for something to go wrong.

## Sea cage aquaculture

### Sea cages

Marine sea cage farming was initially developed in sheltered coastal sites around the world. As technology has advanced, marine farms have been moving to open ocean sites. Open ocean sites may reduce conflict with other users of coastal areas, and have more stable water quality, particularly with regards to oxygen. Open ocean aquaculture requires heavy and expensive gear, however, in order to operate successfully.

The Pacific Islands have a plethora of accessible coastal locations, and many of these are fantastic sites for marine finfish farms. Compared to ponds that have been used in Pacific Island locations, sea cages utilise as little as  $\frac{1}{300}$  of the area for the same amount of biomass production. Biomass densities of up to 40 kg/m<sup>3</sup> are routine for milkfish farming in Asia.

Small cages made from plastic drums and wood have been used in several Pacific Island countries, including Papua New Guinea, Solomon Islands and Tuvalu, for the grow-out of wild harvested or imported marine finfish fry; they have been susceptible, however, to cyclone damage. The increase in milkfish production in Southeast Asia has resulted in improved availability of both square but predominately circular sea cages, framed with polyethylene pipe. They are relatively light and flexible (thus resilient with respect to wave action), can be constructed onsite with relatively simple workshop tools, and the pipes joined by plastic welding techniques.



Sea cage operations in the Marshall Islands.  
(Image: Ryan Murashige, ©Aquaculture Technologies of the Marshall Islands)

Sea cages are generally moored in a grid system designed to dampen the forces of weather. The longitudinal axis of the grid is positioned across the direction of greatest wave action and current flow in order to maximize water exchange; routinely, a minimum depth of 10 m or so is required. A properly moored sea cage marine farm can withstand wind speeds of up to 150 km/hr.

### *Feeding and operation*

Feeding fish is one of the most significant operations for sea cage farming, and many fish feed best in the early mornings when they have more appetite and are much less likely to let feed float down to the bottom uneaten. This is also a time when staffing can be more challenging. Feed can also be a major cost (often the major cost) of sea cage farming. Therefore, ensuring that the amount of feed given to fish is efficiently converted to fish growth (or weight) is important.

Feeding is often automated, especially in locations where labour costs are high, or for offshore sites where access may be difficult. Feed is delivered as a percentage of the total biomass in the cage each day. For Pacific Island marine farms, feeding can be an onerous task, a small circular sea cage of 10 m in diameter – such as the ones used in the Marshall Islands – can hold a total biomass, at an ethical density, of well over 3000 kg of fish. For moi this could mean feeding up to 90 kg daily into one cage as the fish approach their harvest weight. Transporting the feed to the site and manually feeding this amount, for a production cycle of around 120 days, places a heavy demand on logistics and labour. One 10-m circular sea cage may require an input of 9 t of feed or more for one production cycle, and there are at least 10 cages in Majuro Atoll.

Given the quantities of feed needed for sea cage farming, easy access to pelleted feed is important. So, despite the availability of sites, marine farms can be restricted to locations that have access to agricultural feed mills that produce feed for pigs and chickens, such as in Fiji and New Caledonia. Kiribati and the Marshall Islands partially offset this challenge by producing onsite “wet” pellet feeds that incorporate some locally produced nutrition sources such as coconut and trash fish, but imported ingredients are often still required to achieve efficient growth.

Sea cage farm maintenance through the production cycle involves keeping the nets clean to maximize water exchange through the cage, and keeping the net intact to prevent stock from escaping. Most marine farm sea cages have a double net, the outer net being a predator-preventer net. Sea cages attract seals in temperate zones and sharks in the tropics. Treatment for disease is also a major task, and fish often need to be bathed in freshwater within a cage with a waterproof liner to remove parasites or heal an injury caused by fungal infections.

### *Will sea cage farming become viable in the Pacific?*

Sea cage farming production is an activity that could provide jobs and income in many Pacific Island locations. But the biggest challenge for a sea cage farming project is to produce fish at a price that is competitive with the domestic price of fish available from local coastal and oceanic fisheries. At present, there are only a few places in the Pacific Islands – such as New Caledonia and French Polynesia – where capture fishery prices can be higher than finfish aquaculture production costs. A second option is to produce fish that have a high value in overseas markets, such as the moi farmed in the Marshall Islands for high-paying markets in Hawaii, but this requires direct and reliable access by air, and only a few locations in the Pacific have this type of access. The third option is the use of low technology to reduce the cost of production, but it comes with increased risks and puts a limit on scale.

The demand for marine fish in overseas markets, however, is increasing and Pacific Island coastal fish stocks are under severe pressure. Both factors will continue to drive up fish prices, a trend that is unlikely to be reversed. This demand could also increase the likelihood that sea cage farming will become viable in more places around the Pacific and contribute, along with other aquaculture sectors, to food security in the region.

Milkfish sea cage farming in Kiribati is intensifying, with new links to high demand in China. Red emperorfish and rabbitfish production will move to 40 t annually in New Caledonia as this project looks to validate its costs at a commercial scale, while moi production in the Marshall Islands is affected by the COVID-19 crisis, which has reduced the link to high-paying markets in Hawaii.

This type of work could be something for many young Pacific Islanders, both men and women, to work towards, and could provide opportunities to earn money while maintaining a connection to the ocean. While there are environmental impacts of marine finfish cage farming, their impact can be managed. Thanks to the efforts of the teams mentioned here and to the experience gained from other aquaculture projects, Pacific Island countries and territories could promote an industry in line with what they have done so well for centuries: using the bounty of the ocean for the benefit of their people.

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