# Pilot study on grow-out culture of sandfish (*Holothuria scabra*) in bottom-set sea cages in lagoon

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## Abstract

Although mariculture is relatively new to the Maldives, sandfish culture has been practiced in the country for a little over a decade. Currently, sandfish grow-out in pens is being carried out by island communities on a limited scale.

This study was carried out in the lagoon of Maniyafushi Island, Kaafu Atoll, to determine the growth and survival of hatchery-produced juvenile sandfish cultured in bottom-set cages in lagoon in order to assess the potential use of such cages in small-scale sandfish grow-out operations. It was conducted to assess the growth and survival of sandfish in bottom-set cages in the lagoon without varying stocking density and feeding frequency. Feed was introduced in each experimental cage at the rate of 3% of the total sea cucumber biomass in the cage.

Results of this study showed that the survival was high; mean survival was 97.14%. At the end of the 124-day culture period the animals reached a mean body weight of 147.05g and yielded an average biomass of 1424.64 g $m^{-2}$. The specific growth rate for the culture period was 1.58% $day^{-1}$.

Based on the growth and survival of sandfish in bottom-set cages that were used in this study and the performances of sandfish in other culture systems, it can be concluded that the bottom-set cage is a suitable culture system for small-scale grow-out of sandfish with feed inputs – particularly for the early stages of grow-out. This type of cage can also be used for nursing smaller juveniles in the sea before putting them in sea pens for further growing. Further studies are needed to determine the most suitable cage size and materials, stocking density, culture period and scale of grow-out operation. Pens, bottom-set cages and off-bottom cages can be used in different environmental conditions of the lagoons. These culture systems have the potential for widening sea cucumber grow-out in the country.

## Introduction

Island communities of the Maldives rely heavily on natural marine resources for both their economic base as well as their subsistence. The fisheries sector has played a significant role in employment as well as in foreign exchange earnings in the Maldives for many years. The development of a tourism sector and improvements in transportation have led to the diversification of the Maldivian fisheries sector from the traditional pole-and-line skipjack tuna fishery to hand-lining for yellowfin tuna and harvesting of high-valued reef animals that target tourist resorts as well as export markets. Sea cucumber and grouper fisheries are the most significant reef fisheries today. They provide additional or alternative income to fishers.

Sea cucumber fishery activities in the Maldives began in 1985, with a single shipment of 30 kg of prickly redfish (*Thelenota ananas*) to Singapore. Since then, the fishery quickly expanded, targeting high-valued species like the white teatfish (*Holothuria fuscogilva*) and *T. ananas*. Within a few years, over 16 sea cucumber species, including those that fetched lower market prices, were being harvested. High-valued sea cucumbers in shallower waters are now depleted to the extent that the bulk of these species is now caught at depths ranging from 5–30 m.

A review of the sea cucumber fishery in the Maldives by Joseph (1992) revealed that the stocks of high-valued species were extensively harvested and highlighted the urgent need for managing the fishery. It is believed that in addition to conventional fishery management measures, marine aquaculture (mariculture) is a potential solution to reducing fishing pressure on threatened sea cucumber stocks, while simultaneously meeting market demands. The development of sea cucumber

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mariculture could also provide an alternative livelihood for communities.

Culture techniques for some species of sea cucumbers have been developed and are being used commercially in the Asia-Pacific region. Australia, Philippines, Vietnam and Madagascar have been practicing commercial aquaculture of sandfish (*Holothuria scabra*) at different scales (Bowman 2012; Duy 2012; Lavitra et al. 2009, 2010; Eeckhaut et al. 2008; Olavides et al. 2011; Juinio-Menez et al. 2012) and some Pacific Island countries are trialling small-scale production for community-managed sea ranching (Hair et al. 2011).

Maldives is believed to have an ideal setting for mariculture development, based on the widespread nature of the islands and the availability of sheltered lagoon areas. Although mariculture is relatively new to the Maldives, sandfish culture has been practiced by a single private group in the Maldives for a little over a decade. Currently, the Mariculture Enterprise Development Project (MEDeP), which is implemented by the Ministry of Fisheries and Agriculture (MoFA) and International Fund for Agricultural Development (IFAD), is assisting island communities to grow sandfish in shallow, sandy sea pens (low tide minimum depth: 15 cm). MoFA is also trying to develop other sea cucumber grow-out systems such as submerged bottom-set cage (submerged cage sitting on the seabed) or off-bottom cage (submerged cage sitting on legs) to expand sea cucumber grow-out for island communities. These studies were carried out by Marine Research Centre (MRC) of MoFA and the MASPLAN project (a Japanese Government funded project to formulate a framework for the sustainable development of the Maldivian fisheries sector) to assess the potential use of bottom-set cages in small-scale grow-out of sea cucumber that is carried out by island communities.

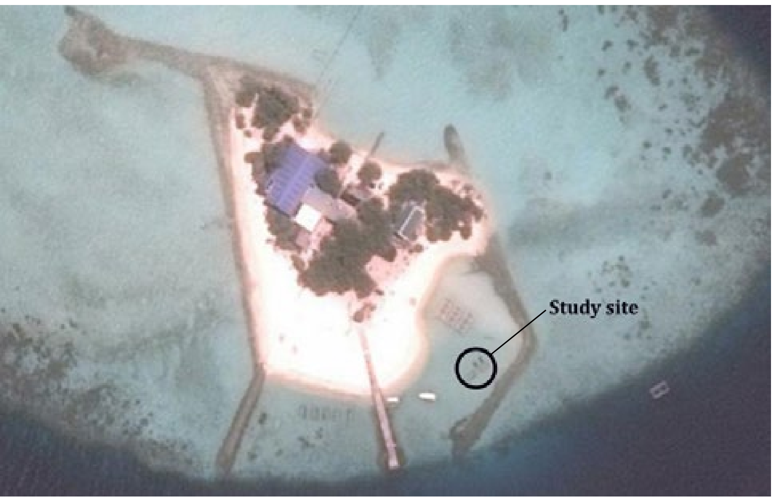


**Figure 1.** Study sites in the lagoon of Maniyafushi Island, Kaafu Atoll.

The objective of the studies was to determine the growth and survival of hatchery-produced juvenile sandfishes that are cultured in bottom-set cages in lagoons in order to assess the potential use of such cages in small-scale sandfish grow-out operations. Submerged bottom-set or off-bottom cages can be used in different environmental conditions of the lagoons. These cages, together with the traditional pen, can be used to widen sea cucumber grow-out in the country.

## Materials and methods

### *Study sites*

The study was carried out in the lagoon of Maniyafushi Island, Kaafu Atoll, Maldives, at the location of the Mariculture Training and Demonstration Facility (MTDF) of MRC (Figure 1). The lagoon was relatively protected from strong currents and waves. It had good water quality and visibility. Tidal fluctuation in the lagoon was approximately 1 m, with a mean depth of 0.5 m and 1.5 m at low and high tides, respectively. The study sites are shown in Figure 1.

### *On land juvenile nursing*

To conduct this study, juvenile sandfishes with a mean body weight of 2.12 g were obtained from a private hatchery. As the juveniles were too small for stocking in sea cages, they were first reared in land-based tanks at a stocking density of 100 individual's $m^{-2}$ for 2 months. During this period the juveniles attained a mean weight of 11.43 g, a size adequate for stocking in sea cages. The rearing tanks had 4–5 mm layer of fine sand at the bottom and continuous water flow at the rate of 6 L $min^{-1}$. They were siphoned daily to remove accumulated wastes and the tank water quality was monitored daily.

### *Sea cage culture*

The study was carried out from August to December 2016 for 124 days. Two rectangular bottom-set cages, each measuring 2.7 m x 1.3 m x 0.5 m (height) and having a bottom area of 3.5 $m^2$ were constructed in this study. The cage walls and bottoms were covered with two layers of nets to make them strong. Nylon nets with a mesh size of 12 mm and 7 mm were used as the outer and inner layers respectively.

A piece of PVC canvas was set on the net at the bottom of the cage. It was raised to a height of 20 cm at the sides of the cage. Fine sand was placed in the cage bottom to a thickness of 10 cm. The top of the cage was covered with a nylon net of 12 mm mesh size. The seawater got in and out of the cage through the top part of the sides (the part without canvas) and through the entire top of the cage. Three sides of top net could be unfastened to get access to the inside of the cage when introducing feed and making daily observations. The cages were labelled as A1 and A2 for identification purposes. They were deployed in a calm site in the lagoon (Figure 1).

From a stock of sea cucumber juveniles, 35 individuals were randomly selected for each of the two cages and placed in them to obtain a stocking density of 10 $m^{-2}$ (Figure 2). Each juvenile was individually weighed. The average weight of the stocked juveniles was 20.6 g.

Feed for the land-based nursing and sea cage culture was prepared at MTDF using locally produced fish meal and imported soybean meal, rice bran, rice, vitamin premix and mineral premix. Microalgae paste was made from microalgae cultured at MTDF and sea grass powder was made from dead sea grass collected from the beach. The composition of the feed is given in Table 1 and Table 2.

**Table 1.** Composition of feed used for land-based juvenile nursing.

| Ingredient | Quantity (g) |
|---|---|
| Fishmeal | 40 |
| Sea grass powder | 20 |
| Rice bran | 15 |
| Soybean meal | 10 |
| Microalgae paste | 14 |
| Vitamin premix | 0.5 |
| Mineral premix | 0.5 |
| Total | 100 |

**Table 2.** Composition of feed used for sea cage culture.

| Ingredient | Quantity (g) |
|---|---|
| Fishmeal | 40 |
| Sea grass powder | 11 |
| Rice bran | 3 |
| Soybean meal | 5 |
| Rice flour | 14 |
| Fine sand | 26 |
| Vitamin premix | 0.5 |
| Mineral premix | 0.5 |
| Total | 100 |

Feed was put in the cages every other day at the rate of 3% of total sea cucumber biomass present in the cage. The cage walls and top net were cleaned of biofouling every two weeks. All the animals in the cage were weighed every month, and the feed amount was adjusted every month based on the biomass in the cage. Weather conditions, water quality, and sea cucumber health were also monitored and recorded.

## Results and discussion

Growth and survival data for sea cucumbers cultured are presented in Table 3, and Figures 3 and 4. The survival was high; mean survival for the two cages was 97.14%. At the end of the culture period the animals reached a mean body weight of 147.05 g and yielded an average total biomass of 1424.64 g $m^{-2}$ (Table 3, and Figures 5 and 6). The specific growth rate (% weight gain $day^{-1}$) for the culture period was 1.58% $day^{-1}$.

**Figure 2.** Juvenile sea cucumbers being stocked in bottom-set cages deployed in the lagoon.

**Table 3.** Growth and survival of sandfish in bottom-set sea cages.

| Indicator | Cage A1 | Cage A2 | Mean |
|---|---|---|---|
| Survival (%) | 100 | 94.29 | 97.14 |
| Mean initial body weight (g) | 20.17 | 21.02 | 20.6 |
| Mean final body weight (g) | 147.86 | 146.24 | 147.05 |
| Specific growth rate (% day$^{-1}$) | 1.61 | 1.56 | 1.58 |
| Biomass yield (g m$^{-2}$) | 1474.36 | 1374.93 | 1424.64 |

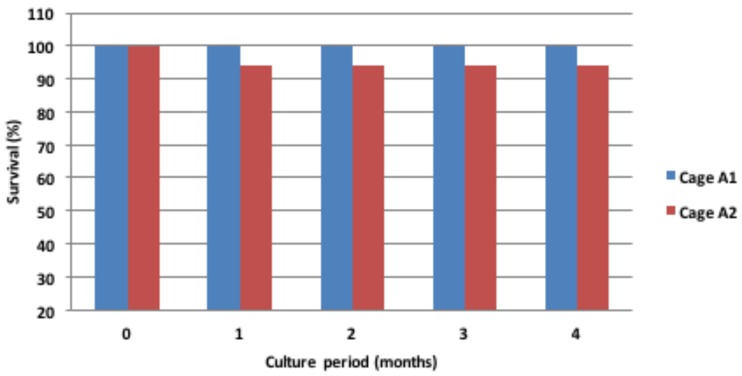


**Figure 3.** Monthly survival of sandfish in bottom-set sea cage culture over 124 days.

**Figure 4.** Harvested sandfish after 124 days of culture in bottom-set sea cages in shallow lagoon.

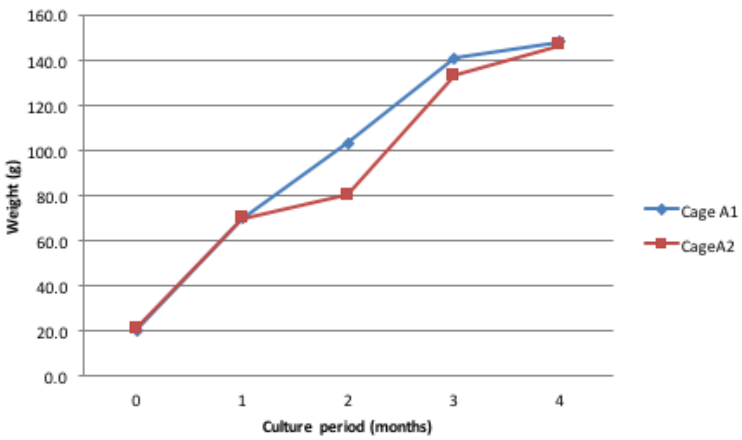


**Figure 5.** Mean monthly growth of sandfish in bottom-set sea cage culture in shallow lagoon.

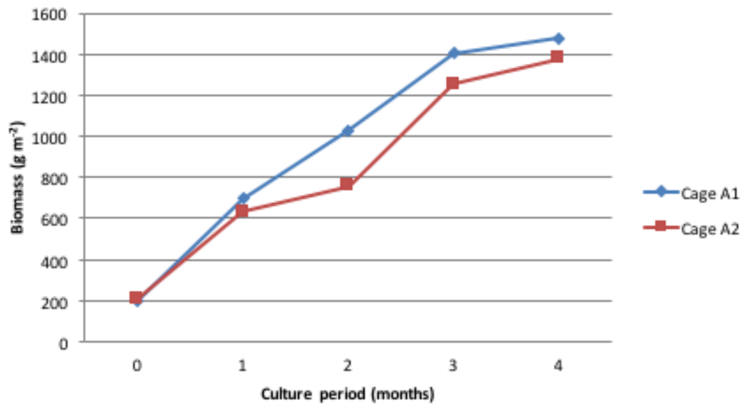


**Figure 6.** Biomass yield per unit area for sandfish cultured in bottom-set cages in shallow lagoon.

Studies on sandfish growth and survival have been done in various culture systems including ponds, sea pens and bottom-set cages (Table 4). However, most of these studies were on culturing sandfish from larvae to juveniles. A limited number of studies has been done on grow-out culture of sandfish (Lavitra et al. 2009 and 2010; Duy 2012; Robinson and Pascal 2011; Bell et al. 2007; Agudo 2012; Purcell and Simutoga 2008; Purcell and Agudo 2013; and Junio-Menez et al. 2016). These grow-out studies were based on extensive methods of culture with no feed inputs. The studies listed in Table 4 differ from the present study in initial weight of the stocked juveniles and length of the study; these studies used smaller juveniles and cultured them for a longer period of time. Due to these differences, comparisons between the listed studies and present study may not be meaningful. However, growth and survival of sandfish in bottom-set cages used in the present study show that this type of cage is a suitable culture system for small-scale grow-out of sandfish with feed inputs.

Pens, submerged bottom-set cages and off-bottom cages require different levels of habitat modification. Pens, when constructed in seagrass areas, require the removal of seagrass to make a favourable sandy bottom for the sea cucumbers. Bottom-set cages make the seabed area immediately under the cage inaccessible to living organisms. The

**Table 4.** Sandfish culture studies carried out in different culture systems.

| Culture system | No. of days | Initial weight (g) | Final weight (g) | Stocking density (ind. m$^{-2}$) | SGR (%BW gain day$^{-1}$) / Absolute growth* (g day$^{-1}$) | Biomass yield (g m$^{-2}$) | Survival (%) | Source |
|---|---|---|---|---|---|---|---|---|
| Bottom-set cage | 124 | 20.6 | | 10 | 1.58/1.0 | 1424.6 | 97.15 | Present study |
| Pond | 56 | 0.24–15 | | 10, 20, 30 and 40 | 0.64/0.22 | 160 | >95 | Lavitra T., Rasolofonirina R. and Eeckhaut I. 2010 |
| Pond | 420 | 2 | 350 | 1 | 1.22/0.83 | 434 | 80 | Duy 2012 |
| Pond | 305 | 10 | 310 | 1 | 1.12/0.97 | 147 | 85 | Duy 2012 |
| Pond | 365 | 11.7 | 400 | 0.8 | 0.96/- | N/A | 70 | Bell et al. 2007 |
| Pond | 360–390 | 0.9–11.7 | 325–395 | 1.6 | 0.9–1.6/0.9–1.0 | N/A | 69–73 | Agudo 2012 |
| Sea pen | 270 | 15 | | 3, 6, 9 and 12 | - | 692 | >95 | Lavitra T., Rasolofonirina R. and Eeckhaut I. 2010 |
| Sea pen | 250 | 15 | 350 | 1 | 1.25/1.4 | 220 | 80 | Robinson and Pascal 2011 |
| Sea pen | 365 | 8–20 | 180 | 3 | 0.6–0.85/1–1.8 | 250 | 7–20 | Purcell and Simutoga 2008 |
| Sea pen | 162 | 21.9 | 106.20 | 0.6 | 0.97/1.09 | 430 | 86.95 | Junio-Menez et al. 2016 |

* Absolute growth was calculated using the data provided in the study reports.

off-bottom cages do not have the inaccessibility disadvantage. Living organism and water current can pass between the seabed and bottom of the cage. Unlike pens and bottom-set cages, an off-bottom cage can be deployed with minimum impacts in areas of coral rubble and patchy seagrass. Various viable sea cucumber grow-out systems allow island communities to conduct sea cucumber grow-out in different bottom conditions of lagoons and minimise habitat modification impacts of the grow-out operation.

## Conclusions and recommendations

Based on the growth and survival of sandfish in bottom-set cages that were used in the study and the performances of sandfish in other culture systems, it can be concluded that bottom-set cage is a suitable culture system for small-scale grow-out of sandfish with feed inputs, particularly for the early stages of grow-out. This type of cage can also be used for nursing smaller juveniles in the sea before putting them in sea pens for further growing. Further studies are needed to determine the most suitable cage size and materials, stocking density, culture period and scale of grow-out operation.

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