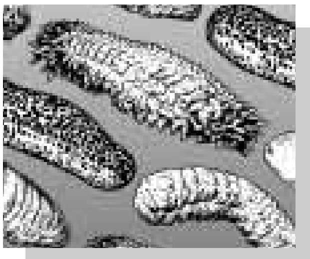

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Preliminary sandfish growth trials in tanks, ponds and pens in Vietnam

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Abstract

Variable amounts of water and ingested substrate held inside the bodies of sandfish may interfere with growth trial data based on weight. On average there is a weight loss of about 4% on drying for 15 minutes, and weight changes of a similar order associated with uptake or loss of sand over 2–3 days. However, individual short-term weight fluctuations are often several times larger.

Sandfish that were kept in bare tanks were fed shrimp pellets or were unfed. All lost weight, the fed animals more rapidly. In tanks with sand, live weights were maintained. There was little difference between the effects of diets based on chick feed or on wheat flour mixed with shrimp pellets, *Gracillaria* seaweed or sea grass. A wide range of finely-ground vegetable materials were eaten and defecated, apparently unchanged.

In ponds, sandfish grew at about 1–3 g/animal/day. Two attempts to look at different densities and different substrates were cut short by major mortalities associated with heavy rain and stratification. There was some indication of a negative density effect and slight advantage of sand over hard or muddy substrates.

Seabed pens built by divers proved useful for holding small numbers of sandfish. Survival was generally very good while growth rates (0–1 g/animal/day) appeared to depend on location as well as density. It should be possible to enclose quite large areas in this way if suitable secure sites can be found.

Introduction

Sea cucumbers of the species *Holothuria scabra*, or sandfish, have received attention as promising candidates for aquaculture and/or stock enhancement (Battaglene and Bell 1999). They are found in shallow inshore waters over a wide range of the tropics and subtropics, and can be used to prepare a high value dried export product. They are, consequently, often over-fished (Conand 1998). There have been a number of studies on the maturity cycle of animals in the natural environment (Ong Che and Gomez 1985; Conand 1993; Tuwo 1999) and methods for stimulating spawning of ripe adults have been described (James 1996; Battaglene 1999; Ramofafia pers. comm.). It appears to be relatively easy, at least in small numbers, to rear the larvae to settlement and beyond.

However, there has been surprisingly little published regarding the growth rates that may be expected from sandfish in culture or nature.

This information is, of course, essential when considering the viability of possible schemes for commercial grow-out or stock enhancement. It is also likely to be of importance in places where stocks of big sandfish are depleted and collected animals may have to be grown to a larger size before they can be used for broodstock.

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This collaborative Sea Cucumber Rearing Project between the Ministry of Fisheries, Vietnam and ICLARM began at the Research Institute for Aquaculture number 3 (RIA3), Nha Trang in June 2000. Locally collected sandfish usually weighed 200g or less. Although they sometimes contained motile sperm or developed oocytes, these small animals proved difficult to spawn when subjected to the usual stimulation techniques; slow or fast temperature changes, drying, water jetting, dried algae, macerated gonad, etc. They were, therefore, stocked in ponds or pens to grow and ripen.

At monthly intervals, or less, groups of sandfish were removed from their pond or pen for spawning attempts. Most of these were returned to the same containers after spawning trials. In addition several groups of small tank experiments were conducted. Results of the first 10 months of work are shown below. Each trial is described briefly, results are summarised or tabulated and problems or conclusions discussed.

Tank trials

Weight changes due to sand and water

Sea cucumbers are notoriously difficult to weigh consistently (and to tag). This was a first attempt to quantify three kinds of weight changes that sandfish undergo. When left out of the water for some minutes they eject some of the water held in the body cavity. When moved between containers with or without substrate they ingest or excrete sand, which is held in the gut. And over a few weeks, somatic growth or weight loss may also occur. It is this last weight change that growth trials need to measure, in isolation from the first two sources of variation. This is particularly important if short growth periods are being used.

Fifteen sandfish, which could be individually distinguished by differences in weight and colour, were used in this trial. They ranged in weight from 60–500g and were selected from a tank where they had been held without sand for 3 days. They were taken out of water and weighed 3 times; immediately, and after 2 drying periods of 15 and 30 minutes in shade. They were then transferred to a shaded outdoor concrete tank containing about 10 cm sand where they were not fed. On the following 3 days they were again weighed immediately after taking out of the water, and after 2 drying periods.

The fifteen sandfish were left unfed in the tank with sand for a total of 30 days, then weighed (after 20 minutes drying) and put into a small bare (fibreglass) tank under partial shade. They were weighed again (shade dried) after 1, 2, 5, 7 and 11 days without feeding in the tank without sand. After 1, 2 and 5 days the excreted sand was collected and weighed (damp). There was some confusion in recording the first day's weighings (14/10). The next 3 data sets were consistent, in that individual sandfish always decreased in weight over the drying periods.

Sandfish expelled water at varying rates, some immediately on being picked up, others after a few minutes. Average individual weight drop due to water released in the first 15 minutes was 4.0%. Over the next 15 minutes there was a further 1.9% average individual weight loss. Overall there was only about 1.2% increase in total weight over 3 days on sand. Over the next 26 days unfed (density 440 g/m^2) there was an average weight loss of 0.48 g/animal/day.

One day after transfer to the bare fibreglass tank 370 g of sand (damp weight) was collected, amounting to 10.8% of the total weight of the animals on transfer. A similar amount of water must have been retained, since the average individual weight loss (after the usual drying period) was only 0.3%. However this average figure hides large and unexplained differences, from individuals that lost about 12%, to those that gained over 20%.

On the following day only 60g of sand was collected (1.75% of total transfer weight), but overall average individual weight loss on that day was 4.2%. The total weight loss over the first 2 days was 5.8% of the total weight stocked in the fibreglass tank. The tank was not siphoned again until day 5, when a further 50 g of sand (1.46%) was collected. However, salinity dropped to 20 ppt due to heavy rain. There was a weight gain, presumably due to water uptake, of nearly 21%. This was later lost, although the salinity remained low. Over the last 9 days unfed in the tank without sand (at a density of 1800 g/m^2), there was an average weight loss of 0.62 g/animal/day.

Sandfish took in or released water somewhat unpredictably. Stress seemed often to lead to large weight increases due to water retention. Weight measurements should, therefore, be made as far as possible when environmental conditions have been stable. Animals should be shade dried for at least 15 minutes before weighing.

The sand contents of adult animal guts amounted to about 14% of the total weight, but the uptake or loss of this sand is accompanied by weight changes of only about 1.2–5.8%. It is apparently balanced in part by the amount of water retained somewhere in the body, even after shade drying.

Table 1. **Weight changes due to water expelled by sandfish when dried for short periods**

Date		14/10/00			15/10/00			16/10/00			18/10/00	
Days with sand					1			2			3	
Days without sand		3										
Dried (minutes)		11-18	31-35		14	27		16	31		15	30
Total weight (g)	3600	3640	3570	3805	3650	3563	3835	3627	3554	3831	3716	3610
Av. weight (g)	240	243	238	254	243.3	238	256	241.8	237	255	248	240.7
Av. % weight change		2.2	-2.6		-4.3	-2.0		-5.0	-1.4		-2.6	-2.3

Table 2. **Weight changes when sandfish were moved to a tank without sand**

Date	13/11/00	14/11/00	15/11/00	18/11/00	20/11/00	24/11/00
Days with sand	30					
Days without sand		1	2	5	7	11
Salinity (ppt)	~30	~30	~30	20	~25	18
Dried (min)	20	20	20	20	30	22
Total weight	3421	3346	3222	3879	3263	3138
Av. weight (g)	228.1	223.1	214.8	258.6	217.5	209.2
Av. individual wt. change (%)	-5.6	-0.3	-4.2	20.9	-15.4	-5.7
Sand weight (g)		370	60	50		

In the trials described below, when animals without sand were stocked on a sand substrate the initial weight was increased by 3.5% (mean figure of the above range) in the calculation of growth. (This of course led to a decrease in the calculated growth rate.) Data to which this correction factor has been applied are shown below in italics.

Effect of shrimp feed on sandfish in bare tanks

Recently-collected sandfish were held in fibreglass or concrete tanks for one week and then divided into 6 matched groups of 12 animals, weighed and stocked in bare concrete tanks (120 cm diameter, 60 cm water depth, outdoors under partial shade). Animals averaged 157 g at the start of the experiment, and mean stock density over the course of the trial was 1390 g/m^2.

Three tanks were fed every second day with 10 g/tank of Betagro 503 (50% protein juvenile shrimp food), while the other three were left unfed. All tanks were cleaned every second day and underwent similar partial water changes (about 50%) before any feeding took place. All animals were weighed on 3 subsequent occasions over 33 days.

The small feed granules became soft but remained visible on the tank floors. There was no sign that the food was consumed, apart from a possible slight increase in the small amounts of faeces produced. Average weights in fed tanks dropped from 157 g to 97 g (mean density 1300 g/m^2) while in unfed tanks they fell from 158 g to 113 g (mean density 1400 g/m^2). Weight loss rates were markedly higher in fed tanks (1.81 g/animal/day) than in unfed tanks (1.38 g/animal/day), with $0.1>P>0.05$ (2-tailed t-test).

This is clearly not an effective way to grow sandfish. Despite very low feeding rates (average 0.3%/day dry food:live biomass), this feed, designed for a largely carnivorous species, appeared to have a negative effect. Also, although no sandfish died, by the end of the trial eleven from the fed and eight from the unfed tanks had become sick, with skin lesions that exuded white mucus.

Effect of four different diets on sandfish in tanks with sand

Four matched groups of ten sandfish from a tank without sand were weighed (after 20 minutes drying in shade) on 9 November 2000. They were stocked in 250 flat-bottomed fibreglass tanks (80 cm diameter x 50 cm depth) with fine white sand to a depth of about 5 cm.

On alternate days partial water changes were made and tanks were fed 10 g of one of four moist pelleted diets scattered (as small soft particles) over the sand surface. In general, waste food and faeces were left in the tanks. On only three occasions the sand was stirred, water swirled and waste materials were siphoned out from the centre of the vortex.

The diets used were:

1) Ground baby chick feed (18% protein), mixed with water and red food colouring, pelleted, stored frozen;
2) Prawn feed Betagro 503 (50% protein) mixed with an equal weight of wheat flour, ground up, and mixed with water and purple food colouring, pelleted, stored frozen;
3) Three parts nearly dry *Gracillaria verrucosa* mixed with two parts wheat flour, minced and mixed with water with blue food colouring, made into dough, stored frozen;
4) One part seagrass leaves, blended and partly drained, mixed with two parts wheat flour and green food colouring into stiff dough, stored frozen.

Tanks were kept outdoors under partial shade until 24 November. They were then moved indoors until the end of the trial, due to heavy rains. There was no feed given for the last 2 weeks, from 5–19 December.

The initial weights have been increased by 3.5% to correct for the absence of sand in the animals at the beginning of the trial. Results are shown in Figure 1. Overall there was little difference between diets 1, 2 and 4. Animals in all tanks lost weight during the first week of December, but regained it during the next 2 weeks, despite being indoors and unfed for that period.

The fact there was no overall weight loss, despite the high average stocking density (2580 g/m^2), may partly be due to the presence of sand, in contrast with the results of trial 2. However in trial 1 sandfish that were unfed in a tank with sand at considerably lower density lost some weight.

This un-replicated trial can only serve as a pointer for more rigorous work. However it seems that not much reliance can be placed on this type of tank trial, where weight changes are tracked over a short period. For sandfish, unpredictable short-term fluctuations tend to overwhelm any underlying effects that different treatments may have.

Feeding observations

In the course of numerous attempts to stimulate spawning, groups of sandfish were held in a bare fibreglass tank for several days at high density (typically over 4 kg/m^2). Among other things, chopped and blended mixed seaweed was tried as a spawning stimulant and left overnight in the tank. It was seen to be the main constituent of faeces the following day, apparently undigested. However seaweed that was chopped by hand without blending was not defecated in noticeable amounts. Subsequently, a number of other potential food materials were tried. These included commercial animal feeds, seaweeds, seagrass and terrestrial vegetables.

Typical sandfish faeces are of 'string of pearl' appearance. The binder or membrane that holds them together is apparently concentrated in the outer layer. Once this is opened there is little cohesion, and the contents can easily be dispersed and examined.

Feed materials given to sandfish without sand in their guts comprised the main faecal content within 8–12 hours. Usually the particle sizes and colour appeared unchanged, so that faeces from green algae or cabbage leaves were bright green, while those from carrot or pumpkin were orange.

Faecal colour is an indicator of food transit time, at least under these somewhat unnatural conditions. It would be of interest to know how much is being digested and assimilated. Perhaps this could lead to the development of practical sandfish feeds based on agricultural products or food processing wastes.

Pond trials

Ponds (and pens) were used to hold sandfish and grow them until they could be spawned. The frequent movement of stock to and from ponds is not ideal for growth trials, however, all such transfers were recorded. Weighing conditions were standardised as much as possible, and weighing was performed before any stressful event such as transportation, and after shade drying for at least 15 minutes. In calculations of growth rates, 3.5% was added to weights of those sandfish that had been held for some days in tanks without sand. (Numbers where this correction has been applied are shown in italics.) Average growth or biomass increases were determined and the number of animal growth days contributing to them was summed. Biomass increase per animal stocked or mean daily growth rates was calculated.

Growth in shrimp ponds with a sand substrate

Two ponds situated beside Cam Ranh Bay, about one and a half-hours drive south from RIA3, were rented from a farmer who was growing shrimp, groupers and babylon snails. He undertook the management of the ponds when used for sandfish experiments.

Pond 1, of 250 m^2, had recently been emptied after a crop of carnivorous babylon snails (*Babylonia areolata*) and appeared highly eutrophic at the start, with heavy phytoplankton growth and partly-anaerobic floor. Initially no food was given, but later a small amount of shrimp food was fed daily, amounting in total to 20 kg over the whole period. Water changes were tidal only.

After weighing on 12 September, animals were stored for about an hour in baskets standing in the pond. They became very inflated with water, increasing in weight by perhaps as much as 50%. They were rapidly counted out between ponds 1

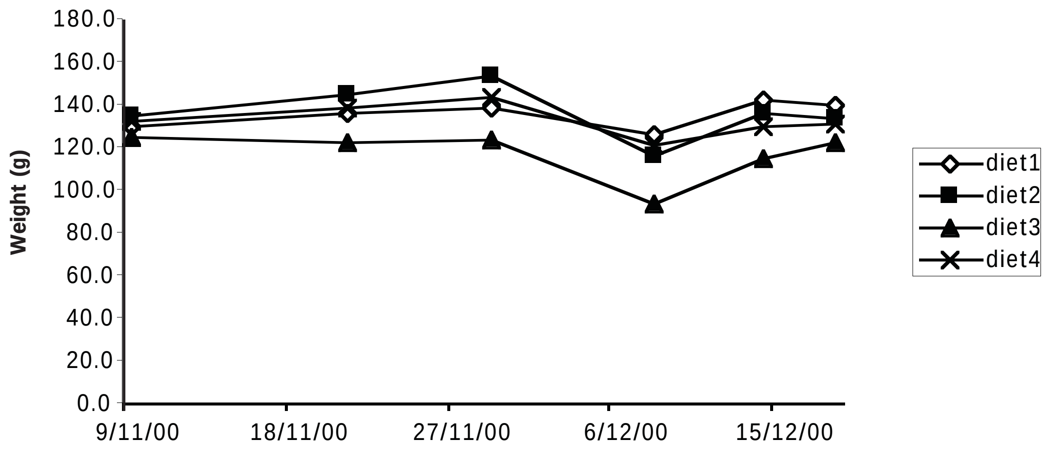

Figure 1. Average sandfish weights with four different diets

Table 3. Materials eaten and excreted by sandfish that were kept in a bare tank (+ indicates that the supplied material is the main faecal component, judged by colour and form)

Material	Result
Chopped and blended green filamentous seaweed (*Enteromorpha* sp.)	+
Chopped and blended red or brown seaweeds (*Sargassum* sp. and others)	+
Chopped mixed seaweeds	-
Shrimp juvenile (Betagro 503) granules	-
Dough from chopped and blended seagrass leaves with wheat flour 1:2 (diet 4, trial 2)	-
Chopped and blended Chinese cabbage leaves	+
Chopped and blended carrot	+
Chopped and blended pumpkin	+
Chopped and blended grass	probable +

Table 4. Weights of sandfish moved in and out of 250 m² sandy pond

	Put in	Put in	Put in	Weighed	Took out	Put in	Emptied
Date	17/07/00	20/07/00	26/07/00	09/08/00	09/08/00	09/08/00	12/09/00
Number	18	93	89	165	7	100	256
Average (g)	*147.8*	*123.8*	*140.0*	152.1	298.6	*134.6*	260.9
Av. growth/animal/day (g)				1.08			3.35

Number put in	300
Number taken out	263
Survival %	88
Approx. density (g/m²)	170
Biomass gain/animal/day (g)	2.11

and adjacent pond 2 (370m²). There was a further weighing, on 2 October when some additional sandfish were also put into pond 2.

On 11 October, after 4 days of heavy rain, there was a problem with the animals in these ponds. In pond 1 the salinity had reached 4 ppt at the surface and 11–17 ppt at the floor, and all sandfish were dead. In pond 2 the salinity was 8 ppt at the surface and 20–30 ppt at pond floor level, and 31% had died.

While 20 days is a rather short period, the results from the two ponds are consistent with each other and with the growth rate in the first period. Until the heavy rain, survival and growth were good despite dense phytoplankton growth, high temperatures and limited water exchanges. Harvesting (by touch, using hands and feet) was made easier by the sandy nature of the pond floor.

Sandfish normally survive salinity levels of around 2 ppt, but it is possible that minimum values during the days of heavy rain were lower than those measured on 11 October. Due to stratification, temperatures below the halocline may have risen and oxygen levels dropped. It is likely that a combination of these factors killed the animals.

Growth of sandfish in pens inside a pond, on 3 substrates at 3 densities

At Van Ninh, about 80 minutes north of RIA3, is a large shrimp farming area. For this experiment a recently-harvested shrimp pond (6000 m²) was rented. The substrate was mainly broken coral with some sand. Part of the pond was subdivided into 12 pens using fine mesh walls. The bottoms of the mesh walls were buried, pegged down and then covered with small bunds rising 10–20 cm above the surrounding pond floor.

This created nine 100 m² experimental pens plus three holding pens of 200 m² each. Soft mud was removed from six of the experimental pens (and also from the holding pens and from the rest of the pond area outside the pens). Sand (50 kg / m²) was spread on the floor of three of the cleaned 100 m² pens.

Thus, the nine experimental pens were of three substrate types, soft (unmodified after harvesting the shrimp), hard (produced by scraping away soft mud) and sand (added after removing mud).

The nine 100 m² pens were stocked at three densities (with 20, 40 and 80 sandfish per pen) on 27 September 2000. The main area of the pond was stocked with babylon snails and fed using dead fish. Water changes were tidal, and no aeration was installed. All sandfish were found to be dead (and decayed) on 12 October after 4 days of heavy rains. The salinity on the surface was 12 ppt, while at the bottom it was 35 ppt and the temperature about 34°C (measured on an overcast day). It is likely that stratification leading to low oxygen and high temperatures in the bottom water layer was the cause of death, rather than low salinity.

A water pump and paddlewheel aerator / circulator were installed and more sandfish collected. The nine experimental pens were subdivided into 40 m² and 60 m² sections, to allow the experiment to be run using smaller numbers (since it was difficult to obtain large numbers of sandfish in the wet season). On 20 December when the pond salinity had reached 25 ppt (after weeks below or near 20 ppt) the experiment was re-started in the nine 40 m² pens. They were stocked at three densities, using groups of 30, 16 or 10 animals per pen.

The contents of the pens were collected by touch and weighed three more times before an unseasonal period of heavy rain at the end of March. Although a paddlewheel was available it had been

Table 5. Weight increase of sandfish in 250m² pond

	Put in	Weighed
Date	12/09/00	02/10/00
Number	120	117
Average weight (g)	260.9	316.3
Average density (g/m²)		137
Average growth/animal/day (g)		2.77

Table 6. Weight changes of sandfish in 370m² pond

	Put in	Weighed	Put in	Removed
Date	12/09/00	02/10/00	02/10/00	11/10/00
Number	136	132	37	119
Average weight (g)	260.9	324.8	177.8	266.3
Average density (g/m²)		106		
Average growth/animal/day (g)		3.20		-2.93

partly dismantled and was not used for several days. Stratification again developed, accompanied by hot, foul conditions near the pond floor, with plenty of decaying pond weed. Circulation was not improved by the small internal bunds, and the poor quality of 'new' water in the supply channel, which served a large number of other ponds. Once again, there were very large-scale mortalities, bringing the trial to a premature end.

The interim sampling appeared to be fairly complete, but no final check could be made. Due to the apparent early drops in numbers of the high-stocked pens 1 and 6, and the premature collapse of the whole trial, densities over about 200 g / m² were not reached. There were also anomalous counts in 3 and 9. What remains are some indications (not significant using 2-way ANOVA) of higher daily growth rates at low density and on sand.

Table 7. **Weights of sandfish in nine 40m² pens inside a pond, with 3 substrates and 3 stocking rates**

Substrate	1 Mud				2 Hard				3 Sand			
Date (2000–2001)	20/12	13/01	9/02	12/03	20/12	13/01	9/02	12/03	20/12	13/01	9/02	12/03
Number	30	12	13	15	16	11	15	13	10	8	10	11
Average (g)	160.5	180.4	239.5	292.4	176.1	208.2	253.7	286.0	168.4	215.4	267.9	308.9
Daily growth (g)		0.83	2.19	1.71		1.34	1.69	1.04		1.96	1.95	1.32

Substrate	4 Mud				5 Hard				6 Sand			
Date (2000–2001)	20/12	13/01	9/02	12/03	20/12	13/01	9/02	12/03	20/12	13/01	9/02	12/03
Number	16	11	12	15	10	9	9	9	30	17	16	21
Average (g)	173.6	217.1	257.7	279.5	163.9	205.7	264.4	321.1	171.0	216.0	264.5	314.3
Daily growth (g)		1.81	1.50	0.70		1.74	2.18	1.83		1.87	1.80	1.61

Substrate	7 Mud				8 Hard				9 Sand			
Date (2000–2001)	20/12	13/01	9/02	12/03	20/12	13/01	9/02	12/03	20/12	13/01	9/02	12/03
Number	10	6	10	10	30	15	26	24	16	20	11	12
Average (g)	160.7	165.2	277.0	312.2	168.4	196.5	244.0	255.2	166.8	246.4	283.0	310.3
Daily growth (g)		0.19	4.14	1.14		1.17	1.76	0.36		3.32	1.36	0.88

Table 8. **Mean stock densities and overall growth rates**

Pen	1 (mud)	2 (hard)	3 (sand)	4 (mud)	5 (hard)	6 (sand)	7 (mud)	8 (hard)	9 (sand)
Mean observed density (g/m²)	90.5	78.9	59.3	77.8	54.8	122.7	53.1	127.9	90.2
Overall growth rate (g/day)	1.61	1.34	1.71	1.29	1.92	1.75	1.85	1.06	1.75

Table 9. **Pooled mean densities and growth rates**

Density	113.7g/m² (high) 1.47g/day	82.4g/m² (medium) 1.46g/day	55.7g/m² (low) 1.83g/day
Substrate	mud 1.58g/day	hard 1.44g/day	sand 1.74g/day

Problems encountered in pond management

It is clear that pond location and vigilant pond management are of great importance. Salinity levels of around 20 ppt are tolerated, and even lower salinity levels are not apparently in themselves quickly lethal. However, fresh or brackish water floats on the surface of more saline water. The lower layer becomes hot and anoxic, particularly if there is a lot of rotting feed or weed lying on the pond floor. It is not yet known whether paddle-wheels, rapidly deployed, can prevent this situation from developing, or whether blowers, airlifts or other systems of vertical mixing need to be used. Low-salinity surface water can be spilled out at low tide but it is more difficult to effect changes to the water layer in contact with the pond floor, which is where the sandfish live. If the pond is allowed to remain too shallow in the interim period until the tide comes back in, solar heating can be even more rapid. Pumped or tidal replacement water may also be of high temperature, poor quality or low salinity, depending on the pond location.

Pen trials

Initially it was planned to build pens in water shallow enough for construction and maintenance to be done without diving. However, it was hard to find shallow areas of suitable substrate and salinity that are protected against waves and human interference. At locations where lobster or fish cage farming takes place, environmental conditions around the year are better known, and farmers guard against theft by living near or above their cages. Moreover many of the small fishing boats run hookah compressors from their diesel engines, and the fishermen and cage farmers are experienced in underwater work. Pens were, therefore, constructed in two such areas.

Pen trials in a fertile inshore area

Duong De is a fishing village in the same bay as RIA3, about 3 km to the north. There are some lobster culture cages with small huts standing above them, in water with a depth of 3–4 m. Lobster juveniles are collected directly in front of the village and babylon snail pen trials have also been carried out.

There appears to be considerable anthropogenic fertilisation, as well as streams draining the partly-cultivated surrounding hills. Inshore there is some *Sargassum* seaweed, and seawards, a submerged reef offers partial protection. This seemed a most convenient location for about 9 months of the year. However, it is considered too exposed to the open sea for lobster culture during the wet season.

The first 2 pens were constructed here at about 3 m depth (low tide), with emergent netting walls (25 mm stretched mesh), supported inside a framework of bamboo poles. They were without net floors (unlike lobster or babylon pens) to allow the sandfish access to the substrate, mainly sand with some silt. The foot of the netting was buried to a depth of about 20 cm and was pegged down with 40–60 cm bamboo pegs at 75 cm intervals. A row of sandbags was laid around the inside of the net on top of the pegs. Both pens were removed from Duong De at the end of September 2000.

Pen 1 enclosed a seabed area of 6 m x 6 m. It was stocked three times with animals that had been used in spawning stimulation attempts, and was therefore empty of sand. The overall stocking density was high most of the time, although when pen 2 was ready some animals were transferred out of pen 1. Survival was excellent but average weights dropped slightly after adjusting for sand uptake. This was probably due to the high numbers of sandfish, exceeding the natural food production of the small area enclosed (Table 10).

Pen 2 enclosed an adjacent area of 6 m x 11 m of seabed. It was stocked with animals thinned from pen 1 and later twice with new purchases of sandfish. Animals were removed for spawning attempts and then returned, along with a few additional new animals. Survival was again good and there was also some growth with the lower stocking density (Table 11).

Growth of sandfish at an island pen site

Tri Nguyen is a small island (also called Hon Mieu) about 20 minutes boat ride (3 km) from the port of Nha Trang. The site used is a southeast facing pebble beach fringed with seagrass beds and some corals. There appears to be little freshwater influence even during the wet season. From a depth of about 2 m at low water the substrate is mainly sand. Only the staff of a small beach restaurant and recently-constructed babylon hatchery live nearby. There are some year-round fish cages on a raft, and sea-bed Babylon culture cages.

The sandfish pens were constructed at about 4 m depth (low water), in the form of regular 12-sided figures of 40 m^2. They were made from the pen 1 netting previously used at Duong De. After cleaning and repairing this was cut in half longitudinally, making two loops of 43 m circumference and 1.7 m height. For each pen 12 posts were sunk into the sandy ground around a circle of 7.2 m diameter.

Pen 1 initially used 3-m long wooden stakes, which were pile-driven in from a fishing boat. Pen 2 used

Table 10. **Growth of sandfish in inshore pen 1**

	Put in	Put in	Took out	Put in	Took out	Emptied
Date	24/07/00	28/07/00	07/08/00	12/08/00	21/09/00	25/09/00
Number	50	65	60	61	15	98
Average (g)	*223.1*	*243.8*	243.8	*198.7*	263.3	204.2

Number put in	176
Number taken out	173
Survival %	98
Approx. density (g/m²)	530
Biomass gain/animal/day (g)	-0.08

Table 11. **Growth of sandfish in inshore pen 2**

	Put in	Put in	Put in	Took out	Put back	Took out	Emptied
Date	07/08/00	01/09/00	07/09/00	07/09/00	11/09/00	21/09/00	25/09/00
Number	60	104	112	44	70	33	238
Average (g)	243.8	*178.0*	*149.9*	450.5	*335.5*	380.9	239.9

Number put in	302
Number taken out	271
Survival %	90
Approx. density (g/m²)	390
Biomass gain/animal/day (g)	1.56

34 mm galvanised steel water pipes 2 m in length, hammered in by divers. The netting was tied to the posts at 3 or 4 points up to a height of about a metre from the ground. A drawstring through the top of the netting was tightened, pulling the upper half of the netting in towards the centre. (Due to this inward-curved shape the pens also had some fish-trapping effect.) The foot of the net was buried, held down with bamboo pegs and weighted with a row of sacks of stones around the inside edge.

The pens were stocked mainly with sandfish collected from the wild. However, 35 animals from pen 1 were used in a spawning attempt (of which 5 were injected with KCl solution to force evisceration) for a few days. Animals are still being held for future spawning attempts.

Some wooden posts collapsed in May 2001 due to severe worm damage, and were replaced by 1.5-m lengths of 27 mm galvanised steel water pipe. Waves or current caused some damage, tearing the netting at points of attachment to the posts of both types.

Survival was quite good, especially in pen 1, although growth was disappointing, perhaps due to the lower productivity of this area. Wave action, which is sometimes quite strong even at 4-m depth, may have a negative effect on feeding behaviour, or increase energy needs (see Tables 12 and 13 on next page).

Pen walls can probably be made much lower than 1 m and still retain sandfish effectively. This will reduce both cost and stresses on the structure. As long as theft is not a problem, large low pens can probably be built wherever suitable environmental conditions are found. By going to greater water depths the influence of low salinity runoff and waves can be reduced. However, this will increase the dependence on diving with compressed air.

Conclusions

Tank growth trials need to be carefully conducted over quite long periods to smooth out fluctuations due to sand and water content changes. Using wild-caught sandfish in small tanks means that stocking densities are likely to be high. Unless effective diets become available, animals are more likely to lose than gain weight in tanks. A supply of juveniles or very small adults will probably be required if meaningful controlled tank-based experiments are to be carried out.

Table 12. **Growth of sandfish in island pen 1**

	Put in	Put in	Took out	Replaced	Weighed	Weighed
Date	03/11/00	09/11/00	30/01/01	05/02/01	23/03/01	07/05/01
Number	25	25	35	35	45	45
Average weight (g)	*250.6*	*207.1*	270.4	*238.8*	273.7	267.6
Average growth/animal/day (g)			0.49		0.07	-0.11

Survival (%)	90
Approx. av. density (g/m²)	275
Overall growth/animal/day (g)	0.21

Table 13. **Growth of sandfish in island pen 2**

	Put in	Weighed	Weighed	Weighed
Date	09/11/00	30/01/01	23/03/01	07/05/01
Number	50	36	37	38
Average weight (g)	203.3	277.4	263.4	286.4
Average growth/animal/day (g)		0.90	-0.27	0.51

Survival (%)	76
Approx. av. density (g/m²)	255
Overall growth/animal/day (g)	0.46

Growth of around 2 g/animal/day appears to be possible in ponds throughout much of the tropical year on a range of substrates, although sand may be best. Mortalities have mainly been due to heavy rain. This can cause hot anoxic conditions to develop below the halocline, leading to total loss of stocks. The problem often shows itself in the first period of fine weather after the rain. If it can be avoided, by aeration or stirring, and perhaps by changing bottom as well as top water, then sandfish appear to tolerate quite a wide range of water conditions.

They can live in water with salinity levels around 20 ppt for weeks and will probably survive shorter periods at lower salinity. High, midday water temperatures in shallow or partly-drained ponds, do not appear to cause problems.

Pens have also proved quite effective for holding and growing sandfish. Where local fishermen or aquaculturists work underwater using hookah equipment, the additional difficulty of deeper sites may be offset by more stable conditions and security advantages.

In ponds and pens most, growth rates fall in the range 1–3 g/animal/day. Figure 2 indicates an inverse relation between density and growth, although this has yet not been tested at high densities in ponds due to shortage of animals. Site effects in pens need to be studied further.

References

Battaglene, S.C. 1999. Culture of tropical sea cucumbers for stock restoration and enhancement. Naga, The ICLARM Quarterly (Vol 22, No.4) October–December 1999.

Battaglene, S.C. and J.D. Bell. 1999. Potential of the tropical Indo-Pacific sea cucumber, *Holothuria scabra*, for stock enhancement. In: E.S. Moksness et al. (eds). 'Proceeedings of the First International Symposium on Stock Enhancement and Sea Ranching', Blackwell Science. 478–490.

Conand, C. 1993. Reproductive biology of the holothurians from the major communities of the New Caledonian lagoon. Marine Biology 116:439–450.

Conand, C. 1998. Overexploitation in the present world sea cucumber fisheries and perspectives in mariculture. In: R. Mooi and M. Telford (eds). Echinoderms: San Francisco. A.A. Balkema, Rotterdam: 449–454.

James, D.B. 1996. Culture of sea-cucumber. Bull. Cent. Mar. Fish. Inst. 48:120–126.

Ong Che, R.G. and E.D. Gomez. 1985. Reproductive Periodicity of *Holothuria scabra* Jaeger at Calatagan, Batangas, Philippines. Asian Mar. Biol. 2:21–29.

Tuwo, A. 1999. Reproductive cycle of the holothurian *Holothuria scabra* in Saugi Island Spermonde Archipelago, Southwest Sulawesi, Indonesia. SPC Beche-de-mer Information Bulletin 11:9–12.

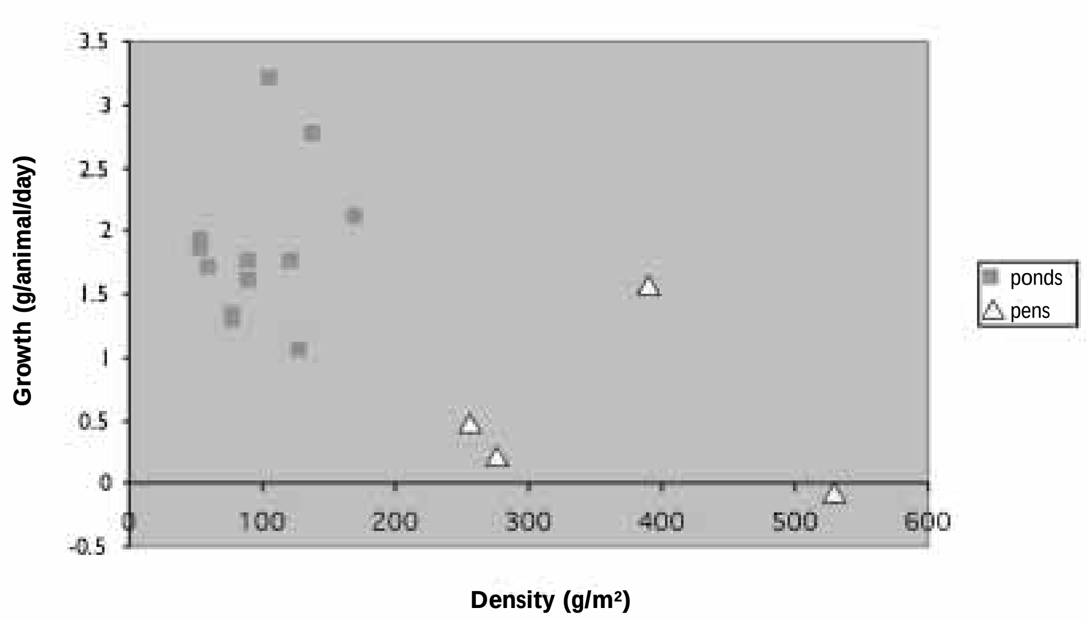

Figure 2. **Density and growth of sandfish in ponds and pens**

The new Marshall Islands Science Station inaugurates a sea cucumber aquaculture research programme

Jean-François Hamel[1,2] and Annie Mercier[1,2]

Iokwe!

The College of the Marshall Islands (CMI) initiated construction of a multi-disciplinary research station in January 2001, marking the embryonic phase of their research programme in aquaculture and stock enhancement. Like many Indo-Pacific nations, the Marshall Islands has been dealing with foreign interests in the exploitation of their holothurian resources and there is imminent danger of local over-exploitation of the most valuable species. Among them, *Thelenota ananas* and *Holothuria nobilis*, which are easily harvested from shallow coastal waters. The new research program will consequently encompass holothurian aquaculture and restocking studies, as well as similar work on other marine creatures of commercial and ecological value. Additionally, the new facilities will foster marine science education and the development of a training and demonstration centre to promote awareness of marine resources preservation and management in the local communities.

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