Development of an Integrated Multi-trophic Aquaculture (IMTA) for Tropical Species in southern Cebu, Philippines

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Background

The world's demand for fish and other seafoods relies mainly on **capture fisheries.**

But capture fisheries alone is no longer sustainable due to world's dwindling fish stocks.

Background

Aquaculture is the future of food security in the 21st century .

(Godfray et al. 2010. Food Security : The Challenge of Feeding 9 Billion People. *Science* 327:812-818).

Background

Aquaculture fills the gap in meeting the world's rising demand for fishery products (FAO 2014).

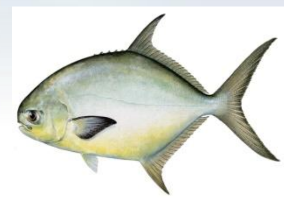
BUT, aquaculture has also been criticized for many of ecosystem's failure where extensive use of feeds also contributes to water quality deterioration.

The IMTA Concept

Integrated Multi-Trophic Aquaculture (IMTA) may well be the answer to the potential collateral negative impact of fed aquaculture to ambient seawater quality.

“Multi-trophic” means involving species of different trophic levels

Feed



Fed species

Wastes:

- metabolic release
- uneaten feeds
- feces

Inorganic

NO_3, NH_4, PO_4

Organic

POM, DOM

Inorganic extractive species

Organic extractive species

The IMTA Concept

Desirable species for IMTA:

- those that have high economic value
- those with extractive capacity for inorganic and organic wastes generated by the fed species

Feed

Fed species

Donkey's ear Abalone (*Haliotis asinina*)

Wastes:

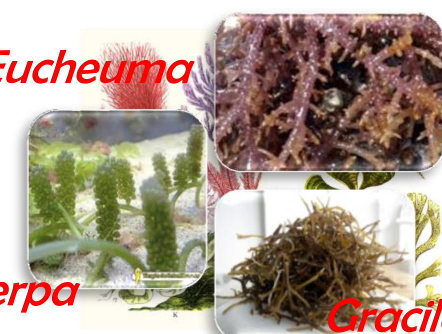
- metabolic release
- uneaten feeds
- feces

Inorganic

NO_3, NH_4, PO_4

Organic

POM, DOM



Eucheuma

Caulerpa

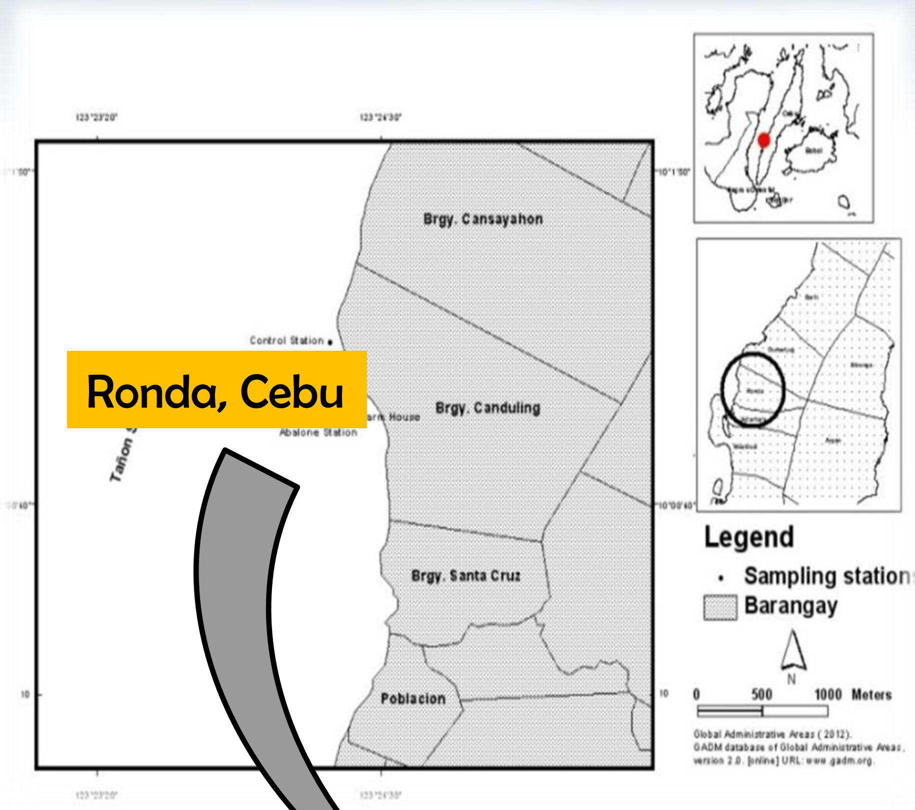
Gracilaria

Inorganic extractive species

Sand fish (*Holothuria scabra*)

Organic extractive species

The Study Site



Ronda, Cebu

Main objective: to develop a tropical IMTA system using locally-available high-value species

Sub-objectives:

1. Determine the growth performance of the IMTA species

2. Monitor water quality (esp. nutrients) within and around the abalone farm

3. Determine the capacity of extractive species to absorb inorganic and organic wastes

METHODOLOGY

1. Cage culture and growth monitoring of donkey's ear abalone.

2-month old (juvenile) abalone @ 1000 individuals per tray

Cage in suspension

5-month old abalone @ 50 individuals per compartment

Cage deployment

Monthly size and weight measurement

10-month old abalone

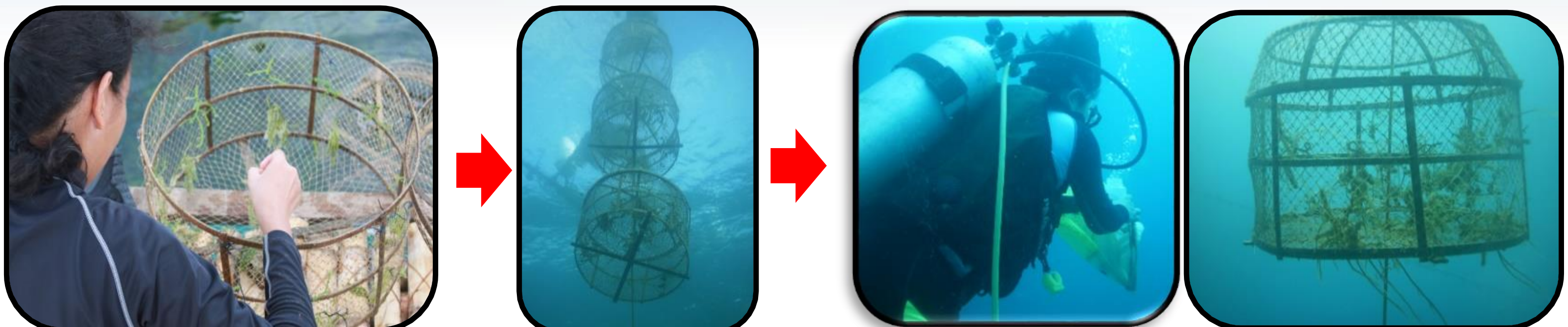
12-month old abalone

Market

METHODOLOGY

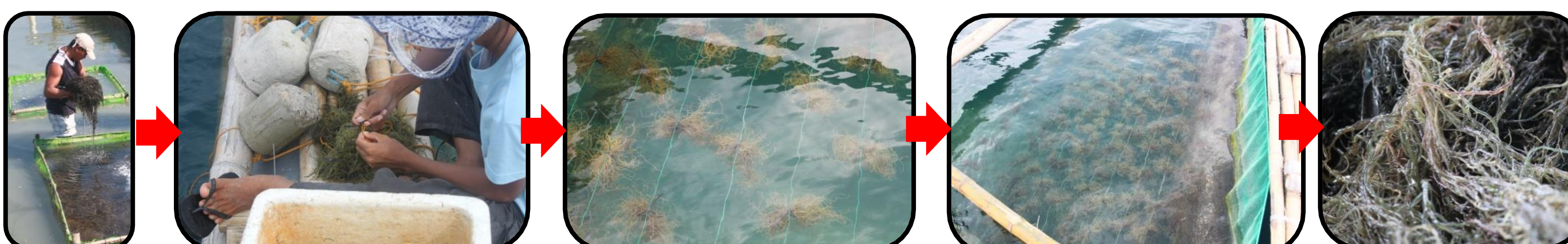
2. Seaweed culture and maintenance

A.



Basket culture of *Caulerpa* ('lato')

B.

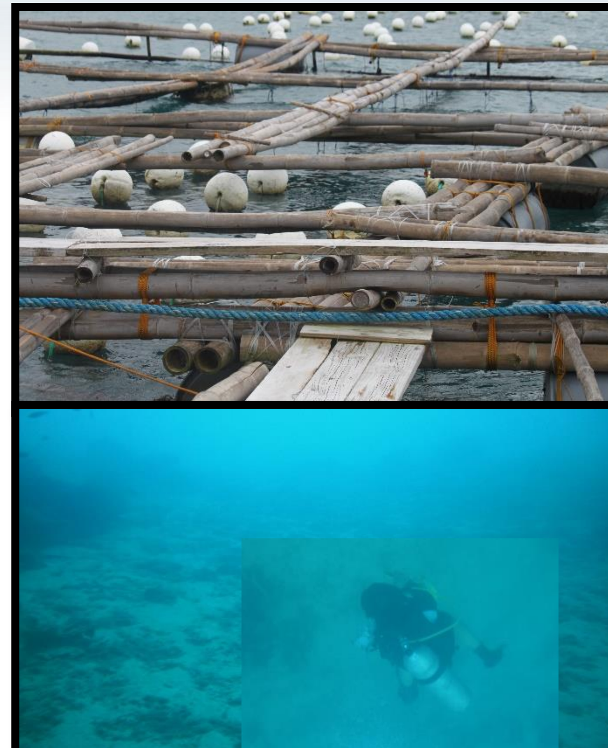


Raft and monoline culture of *Gracilaria* ('gulaman')

METHODOLOGY

3. Deployment of sand fish at the abalone farm

Sand fish *Holothuria scabra* bought from a local fisherman in Bantayan Is., Nov. 6, 2013.

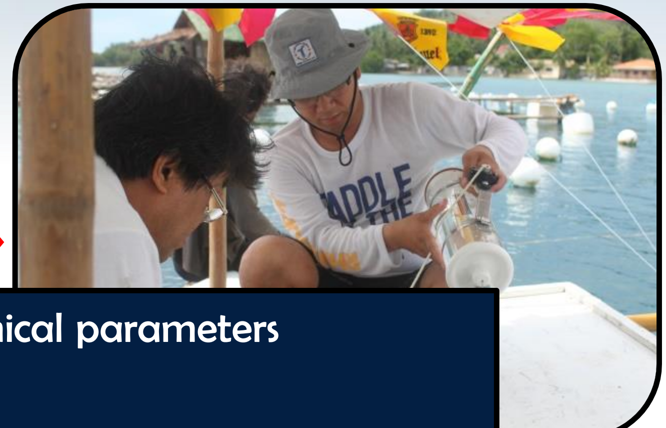


Deployment of sand fish in the sea bed under Presito abalone farm, Nov. 9, 2013.

METHODOLOGY

4. Water quality monitoring

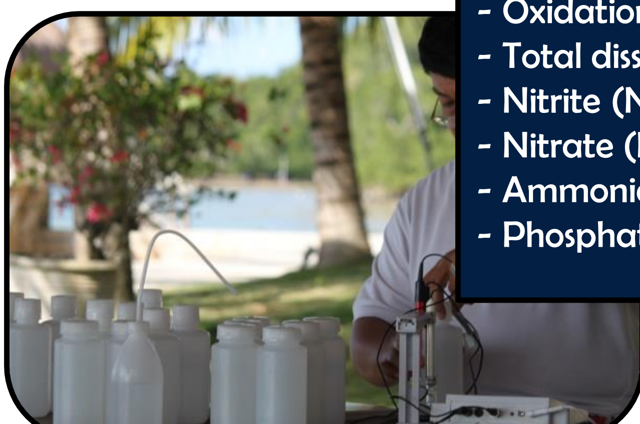
Sampling from 3 depth l



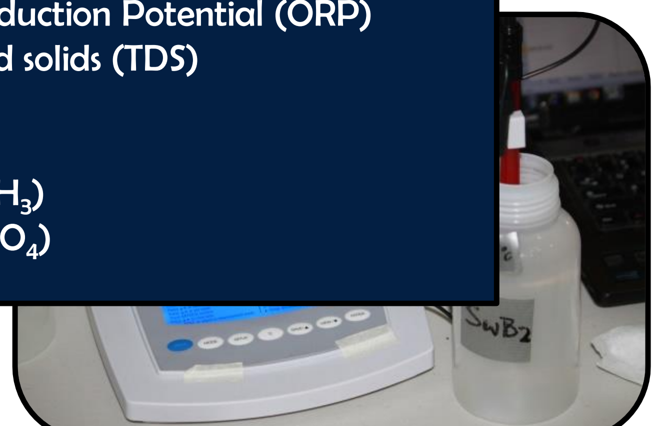
nalysis

Physico-chemical parameters determined:

- Temperature
- Salinity
- pH
- Oxidation-Reduction Potential (ORP)
- Total dissolved solids (TDS)
- Nitrite (NO_2)
- Nitrate (NO_3)
- Ammonia (NH_3)
- Phosphate (PO_4)



pH, ORP, TDS, & salinity measurements



Multi-parameter meter

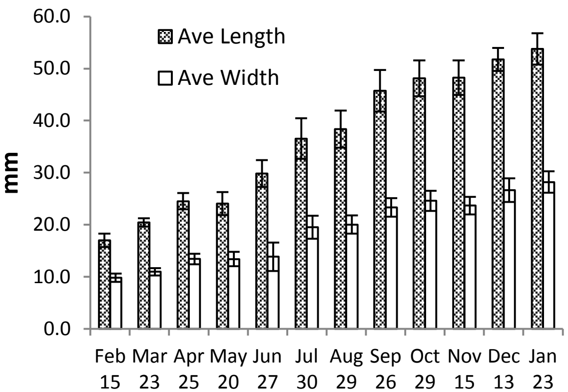
Results

1. Abalone's growth performance: Max. growth was reached after 12 months:

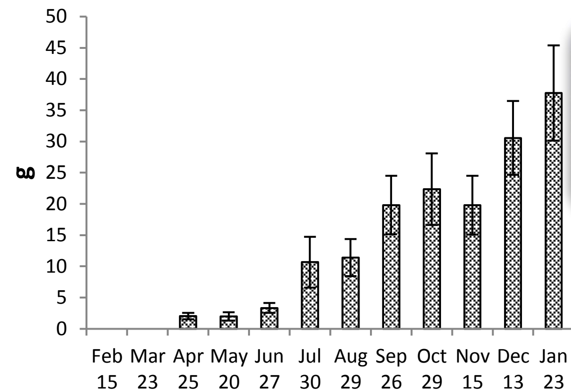
Size of 53.79±3.01 mm SL x 26.7±2.3mm SW (mean, SD); **Body weight** of 37.76±7.61 g (mean,SD)

2-month old juvenile abalones

A. Shell length and width (mm)

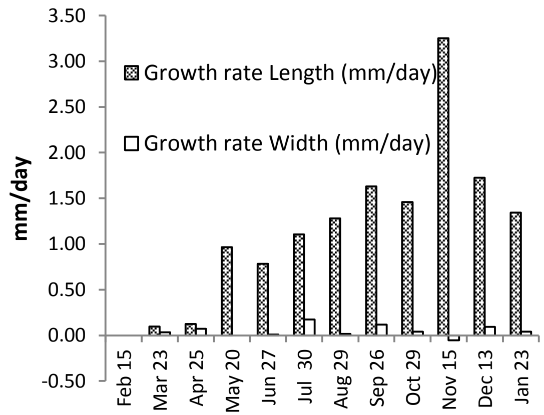


B. Weight (g)

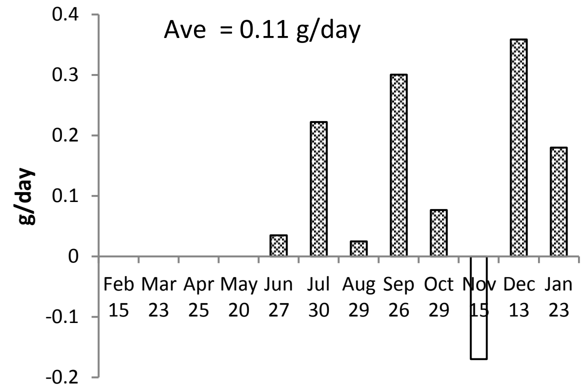


12-month old abalones

C. Growth rate by size



D. Growth rate by weight



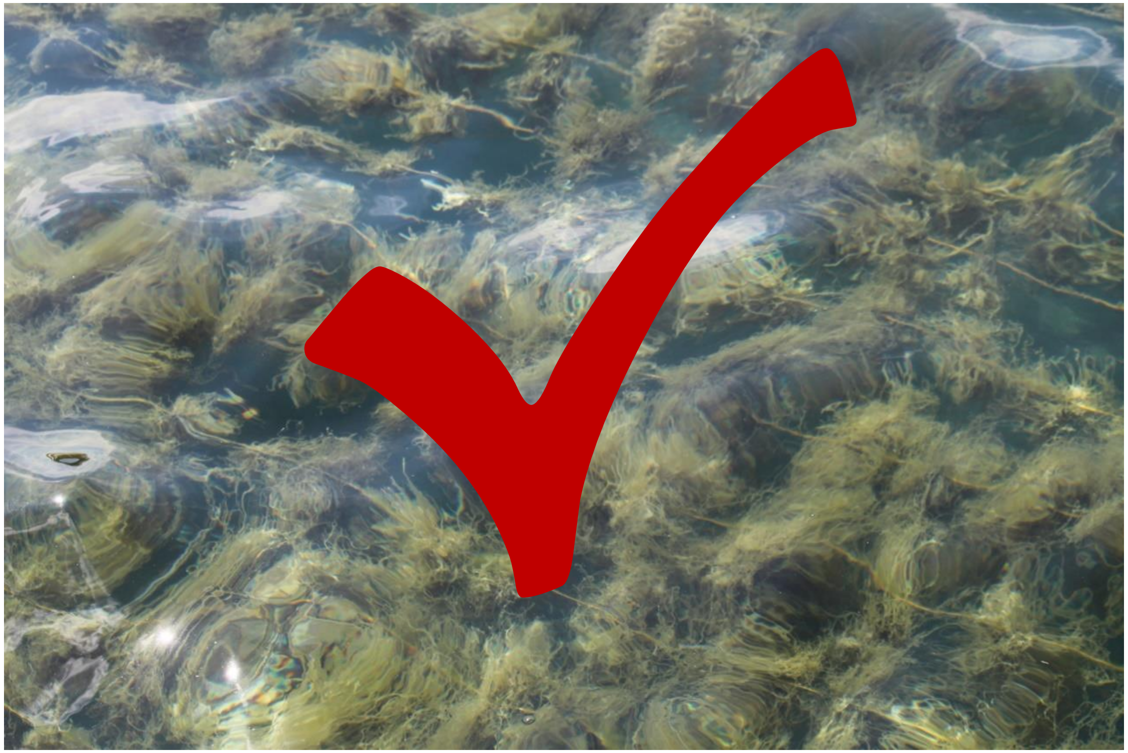
Results

2. *Caulerpa's* growth performance: Little growth; too fragile for open sea maintenance culture.

After two weeks

RESULTS

3. *Gracilaria & Eucheuma* growth performance: can withstand open-sea culture; Ave. Daily Growth Rate: 4% day^{-1}

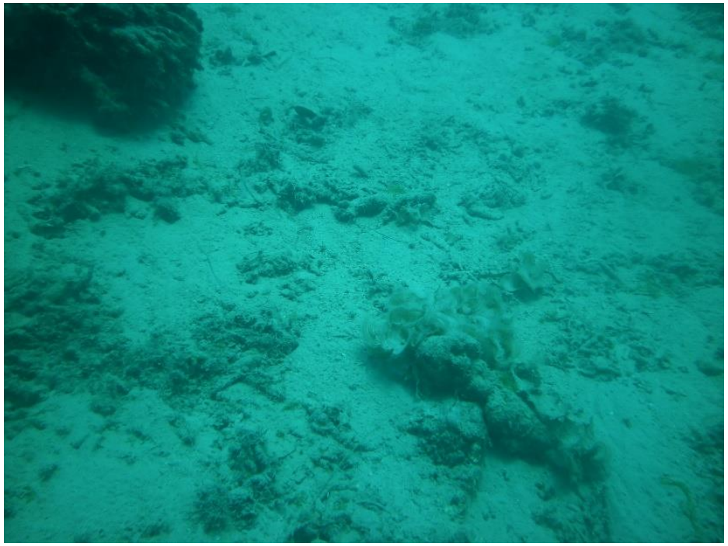


After two weeks

Results

4. Sand fish deployment:

All animals burrowed into the sand and disappear from site.



After two weeks

RESULTS

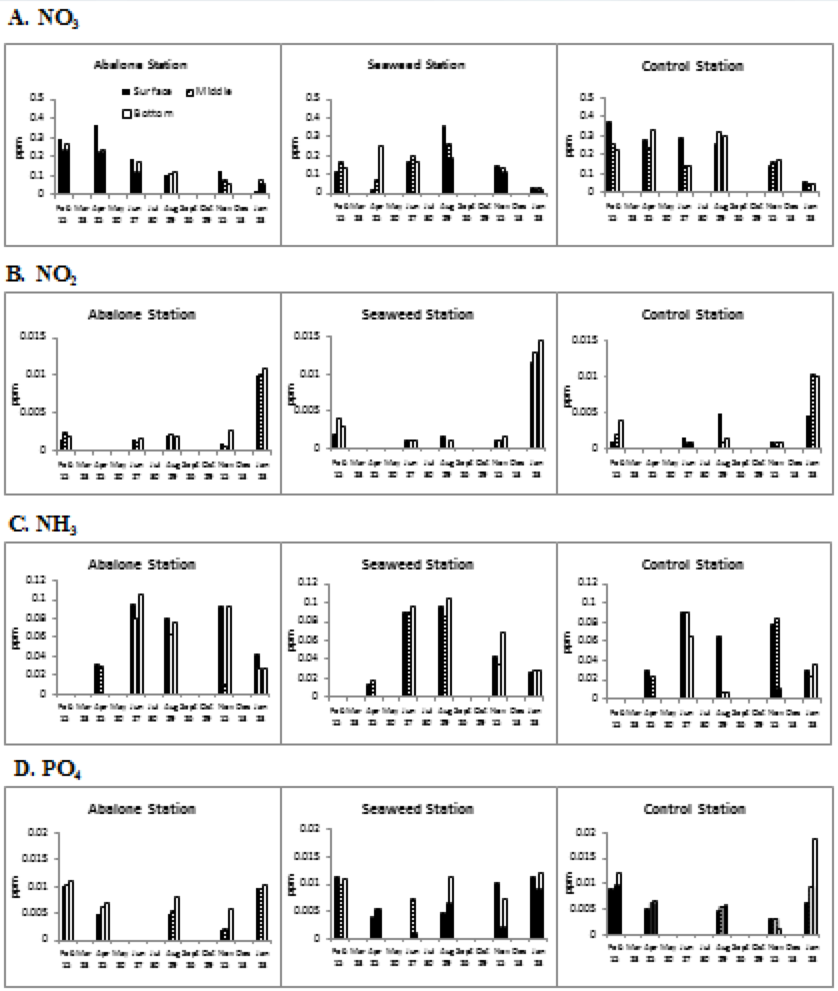
5. Physico-chemical parameter profile of ambient seawater:

Physico-chemical Parameters	Range	One-way ANOVA of monthly samples
Water temp. (°C)	26 – 31	Not significant*
Salinity (‰)	34 – 35	Not significant
pH	8.1 - 8.3	Not significant
TDS (mg/L)	2.9 – 3.8	Not significant
Light penetration (m)	3.5 - 12	Not significant

* $p > 0.05$

RESULTS

6. Nutrient profile in ambient seawater: monthly



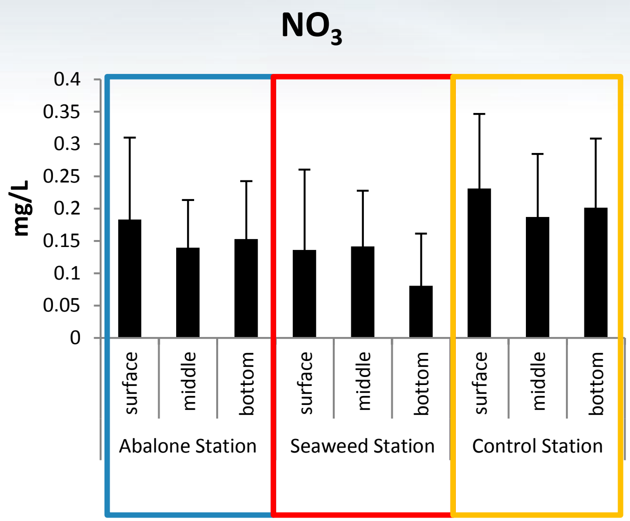
Nutrients (Inorganic waste)	Concentration range	one-way ANOVA of monthly samples	Water quality standard* (based on Australia & New Zealand)***
Nitrate (NO_3)	0.011 to 0.367 mg N/L	Not significant	<100 mg/L
Nitrite (NO_2)	nil to 0.0145 mg N/L	Not significant	<0.1 mg/L
Ammonia (NH_3)	nil to **0.105 mg N/L**	Not significant	<0.01 mg/L
Phosphate (PO_4)	0.001 to 0.019 mg P/L	Not significant	<0.05 mg/L **

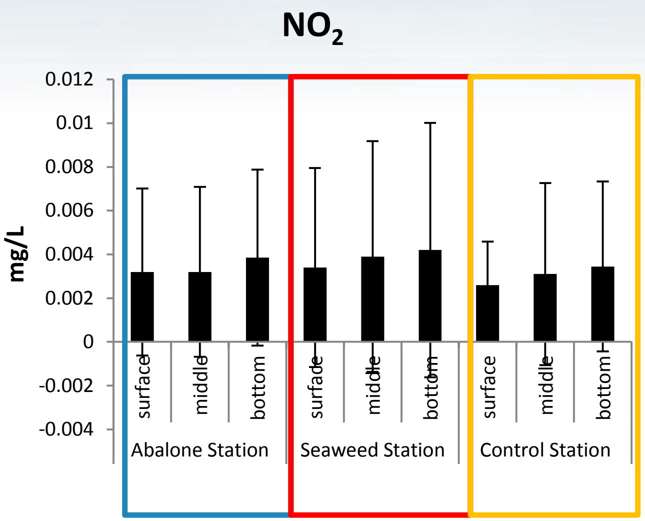
* No water quality standard for Philippines by DENR for nitrate, nitrite and ammonia.
** 'nil' based on DENR Water Quality Standard for marine waters
*** cited in PHILMINAQ (2008).

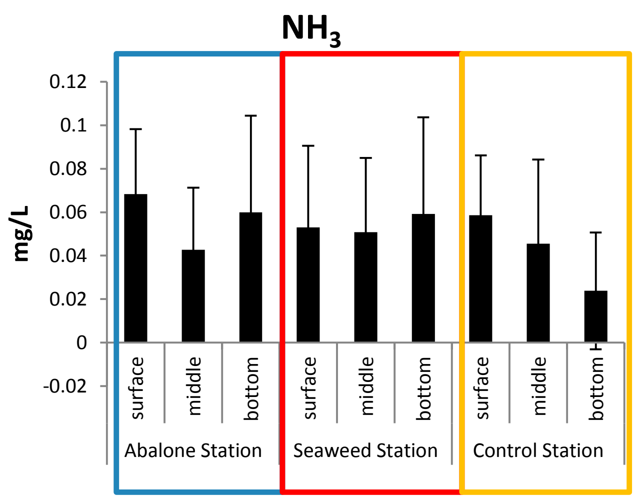
Fig. . Nitrate, nitrite, ammonia, and phosphate content in waters collected from three depths (surface, middle, bottom) at the three stations (Abalone, Seaweed and Control). Only ammonia went above the water quality standard.

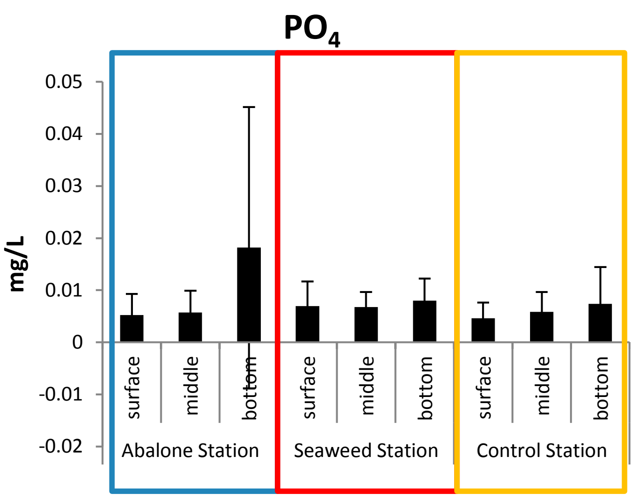
Results

7. Nutrient profile in ambient seawater: 1 year average









Results

8. Nutrient profile in ambient seawater: one year average

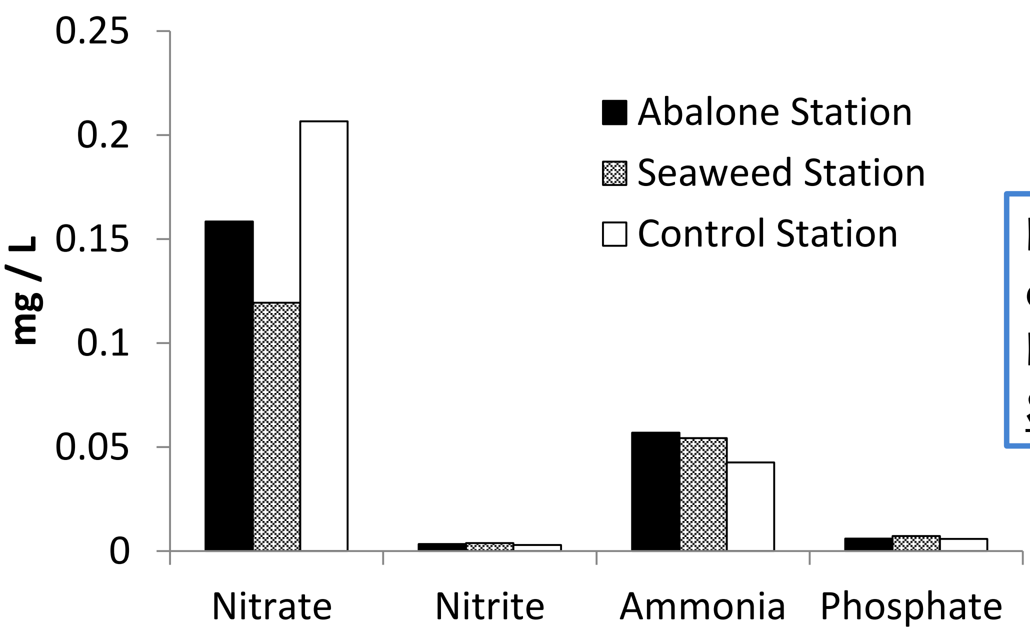


Fig. __. One-year average values for nitrate, nitrite, ammonia and phosphate from water samples taken from the three stations (Abalone, Seaweed and Control Stations).

Nitrate and ammonia concentrations are **high in Abalone Stn** (0.1585 mg N/L) but **relatively low in Seaweed Stn** (0.1403 mg N/L)

Summary of Findings

1. Donkey's ear abalone *Haliotis asinina* could grow to a cocktail size within 10-12 months in cage culture;

2. The red seaweeds *Gracilaria heteroclada* and *Eucheuma denticulatum* are both culturable in open sea using monoline method and are suitable biofilters for excess nutrients;

3. Nitrate and ammonia were produced in noticeable amounts in the Abalone Station, but no accumulation of these nutrients was noted within the Seaweed Station just beside the abalone cages;

4. Sand fish *Holothuria scabra* proved to be difficult to confine in the sea bed under the abalone farm which could be mainly attributed to its burrowing behavior.

Conclusion

- The combination of fast-growing seaweeds, such as *G. heteroclada* and *E. denticulatum* in the abalone culture system, is crucial for the maintenance of a balanced ecosystem as far as inorganic wastes are concerned;

- The growth rate of abalone in open sea cage culture can reach harvestable (cocktail) size within ten months to one year;

- The incorporation of sand fish (*Holothuria scabra*) being a burrowing species still needs to be optimized to effectively serve as an organic extractive IMTA species.

Conclusion

Based on the above findings, the concept of IMTA has been found in this study to have worked well

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The IMTA concept should be therefore promoted in the Philippines as an environmentally responsible and sustainable concept of aquaculture which could provide a good source of livelihood for the Filipinos.

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when … a good source of livelihood for coastal communities at little, if not, no expense to the environment.

For some details, please see this study in its published form:

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Development of an integrated multi-trophic aquaculture (IMTA) system for tropical marine species in southern cebu, Central Philippines

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ABSTRACT

This study presents the establishment of an integrated multi-trophic aquaculture (IMTA) system in the tropical open waters of southern Cebu, Philippines using a combination of locally available species, namely donkey's ear abalone (*Haliotis asinina*) as fed species and seaweeds (*Gracilaria heteroclada* and *Eucheuma denticulatum*) as inorganic extractive species. The culture of *Caulerpa lentillifera* as a biofilter did not work in the open sea cultivation system using baskets. Monthly measurements of shell length, width and body weight of the cultured abalones, together with in situ measurements of physicochemical parameters to assess any changes in water quality, mainly nitrate, nitrite, ammonia and phosphate, were conducted over a year period from February 2013 to January 2014 in three designated stations (Abalone, Seaweed and Control Stations) at three different depths (surface, middle and bottom).

Cage culture of abalone side by side with seaweeds in the open sea did not result in any significant water quality disturbance in the area—at least not in the current volume of caged abalones being used. Of the four inorganic compounds monitored in the field, nitrate and ammonia in the Seaweed Station were shown to have relatively lower year-round average values when compared with the Abalone Station, although in the case of nitrate, it was higher in the Control Station compared with the abalone and Seaweed Stations. Although this difference was not significant, it shows the red seaweeds, *G. heteroclada* and *E. denticulatum*, to be functioning as a natural filter for these two nutrients. In contrast, nitrite, and phosphate concentrations were not reduced indicating that the seaweeds were not effective biofilter for these two nutrients.

The two-month old hatchery-bred donkey's ear abalones can grow to a size of 53.8 × 28.2 mm (*L* × *W*) and body weight of 37.8 g after a period of 12 months. Any expansion of the farm into a much larger commercial-scale farm will have to be complimented with seaweeds stocked around it if only to mitigate possible build-up of excess inorganic wastes—to serve as both a natural filter and as a source of natural feed. The potential use of an organic extractive species has to be further studied under farm condition to achieve its full potential as an IMTA species.

1. Introduction

1999 and will be the only means to meet the increasing demand

We would like to acknowledge:

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