Final report

Pulsar 4400 case study for algae control in shrimp farms

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March 15, 2024

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1. Introduction

Ecuador is the world's leading shrimp producer.
The Ecuadorian shrimp industry occupies 233,000 hectares or 2,330 km^2.

- ✓ Ecuador has favorable conditions for shrimp cultivation.
- ✓ Tropical climate with high temperatures and humidity.
- ✓ Good water quality thanks to extensive mangroves that act as natural filters and an abundance of native species.
- ✓ Abundance of native species such as Pacific white shrimp or vannamei (*Penaeus vannamei*).

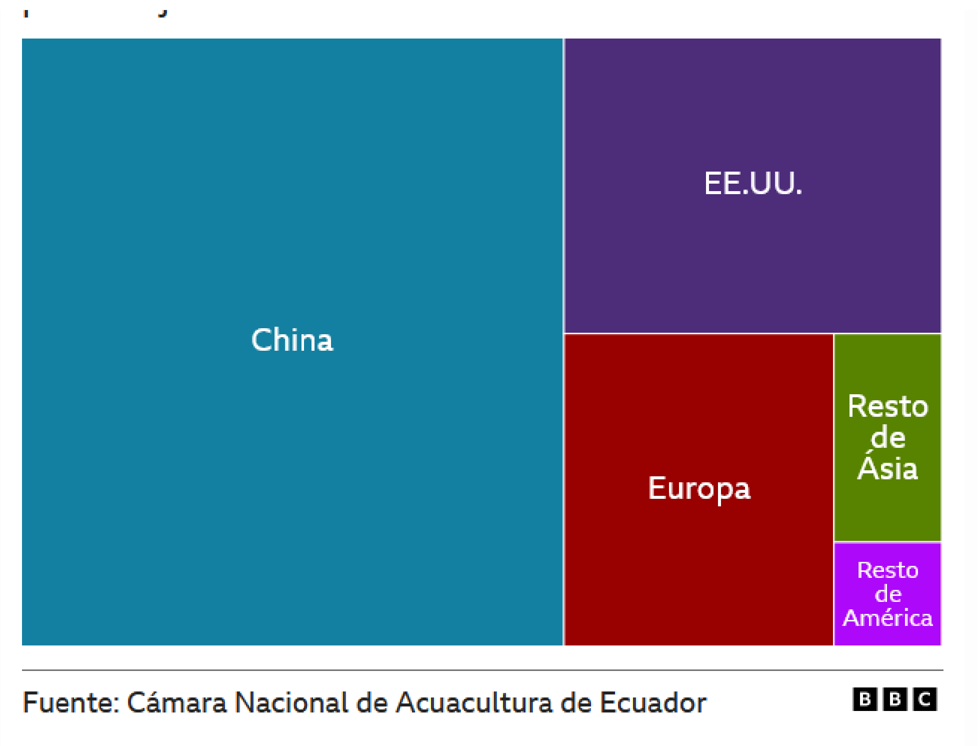
Camarones recién pescados en la granja que visitó BBC Mundo en Taura.

1. Introduction

Ecuador is the world's leading shrimp producer.
The Ecuadorian shrimp industry occupies 233,000 hectares

Ecuadorian shrimp exports, 2012-2022

Ecuadorian shrimp exports in 2022



1. Introduction

Naturisa S.A.

The company Naturisa S. A. is dedicated to the exploitation of shrimp hatcheries (shrimp farms), shrimp larvae hatcheries (shrimp larvae laboratories).

Naturisa S.A. is a family company established in 1987, it started as a medium-sized farm covering 130 hectares of land, whose corporate purpose is the exploitation of shrimp larvae and other bio-aquatic species through the installation of laboratories and pools.
In 1991 the main shareholder of Naturisa S.A. acquired the entirety of **Sociedad Nacional de Galapagos SONGA S.A.,** one of the oldest companies in local and international commercialization of seafood products in the country.

Naturisa currently has 5,400 hectares of land suitable for the cultivation of underwater species, which allows it to supply **SONGA S.A.** in its entirety, a company that ranks among the top five shrimp exporters in the country, according to the Quito Stock Exchange (2015).

The company has diversified by incorporating the agroindustrial sector into its line of business, which includes cocoa, mango, and lemon farms and, to a lesser extent, poultry farms; however, the aquaculture sector is the most important, as it accounts for 97% of the company's revenues.

1. Introduction

Sociedad Nacional de Galapagos SONGA S.A.

Songa is Ecuador's second-largest shrimp exporter

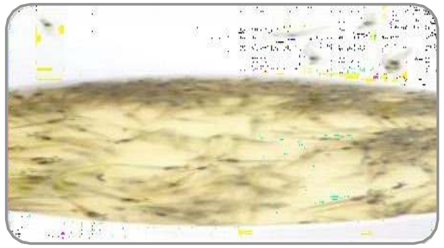
January through November 2022, 2,141′316,957 pounds of shrimp were exported.

They have a team of 2,000 people. We have international certifications

Water for its processes is collected from the Guayas River through a pumping system. Once the water is used at the packing plant, it passes through a high-tech treatment system that ensures that the water is returned to the river in compliance with the requirements of the Ecuadorian environmental authority.

1. Introduction

Shrimp farming



1. The process begins in a laboratory, where male and female broodstock are selected for their optimal genetic conditions. Shrimp can produce thousands or even tens of thousands of larvae in a single clutch.

2. When these grow, they are raised in hatcheries and then deposited in ponds or "pools" in mangrove areas or on land.

3. Two to three months later, the shrimp are harvested, packed and transported.

1. Introduction

Shrimp farming

Shrimp need good environmental conditions to survive and grow. Dissolved oxygen, temperature, pH, conductivity and ammonium are the main factors monitored in this industry.

Parameters	Hypoxia - acid	Under	Normal	Alkaline
Temperature (^0C)	NA	0-25	25-32	NA
Dissolved oxygen (DO) mg/L	0-2	2-5	>5	NA
pH	0-4	4-7	7-9	10-14

NA: Not Applicable

Hernández y Fernández (2013)

They are grown in 1.5 m ponds, in non-intensive stocking densities of around 8 to 10 shrimp/m^2, semi-intensive 10 to 30 shrimp/m^2 and intensive up to 100 shrimp/m^2. The ponds measure between 5 and 20 hectares, they are connected by a system of pumps and gates that allow the recirculation of water between the ponds and the water catchment sources (rivers and/or sea).

They feed on pellets (food based on fish meal, with vitamins, fatty acids and minerals), and on diatoms and other microalgae that live at the bottom of ponds and in the water column.

1. Introduction

The key factor for shrimp is **Dissolved Oxygen (DO)**

Dissolved oxygen (DO) plays an important role in the respiration of aquatic organisms and is affected by the weather, paddle wheels, plankton population, and metabolism of microorganisms.

Sources of DO

- Diffusion from the atmosphere
- Oxygenation by movement of water over rocks or bottom
- Oxygenation by wind or waves
- Photosynthesis by microalgae and aquatic plants

Factors affecting DO levels

- Temperature > T → < OD
- Microalgae (releases oxygen during the day and consumes it at night.)
- Microalgae blooms, when they die they are degraded by bacteria, which consume the oxygen until it is exhausted.
- Stream flow
- Atmospheric pressure and altitude

The ideal DO for shrimp farms is no less than 5 mg/L.

1. Introduction

In shrimp farms the ideal DO is greater than 5 mg/L.

They generally have low oxygen due to the abundance of microalgae blooms.

To avoid low oxygen they have aerators in the ponds.

When there is a lack of oxygen, they use the pumping and gate system, making the water flow between the fattening ponds and the water collection sources (rivers and/or sea). When they have little oxygen they circulate water.

1. Introduction

The problem

Harmful algae blooms in shrimp culture ponds

- Block light for other microalgae that serve as dietary supplements
- Decrease dissolved oxygen
- Produce toxins that even cause shrimp death
- Generate bad taste in shrimp

Main harmful microalgae reported in shrimp farms

Cyanobacteria: *Oscillatoria, Dolichospermumm, Anabaenopsis, Raphidiopsis, Merismopedia, Spirulina, Microcystis, Nostoc, Aphanocapsa*.

Rafidophycea: *Chattonella, Heterosigma*

Euglenas

peroxide and sulfate are applied to control algae; peroxide costs are $150,000 dollars a year and sulfate costs are $31,000 a year

1. Introduction

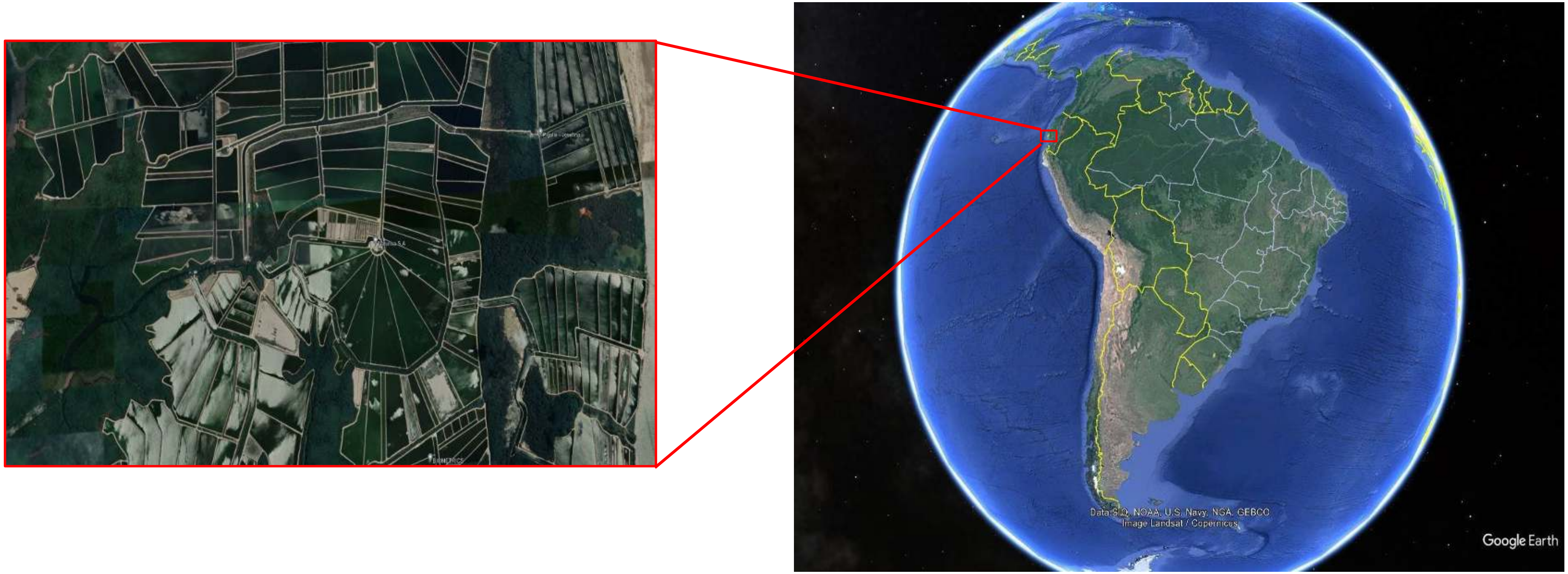
  

Cyanobacteria produce toxins that affect different organs of the body.

Raffidophyceae have been implicated in the production of brevetoxins (PbTx), reactive oxygen species (ROS) and polyunsaturated fatty acids (PUFA), reactive oxygen species (ROS) and polyunsaturated fatty acids (PUFA).
Some species of euglena also generate biotoxins.

2. Methodology

1. Dual Pulsar 4400 installed at Naturisa shrimp far.



2. Methodology

		
Dual Pulsar 4400 indexing and solar panel	Monitoring: Integrated samples	Initial condition Sample taken on November 6 in the pond. Subsequently the water was mixed with water from the settler, to increase the concentration of algae and start the experiment. Diatoms 18% Cyanobacteria 82% (*Oscillatoria* and *Raphidiopsis*)

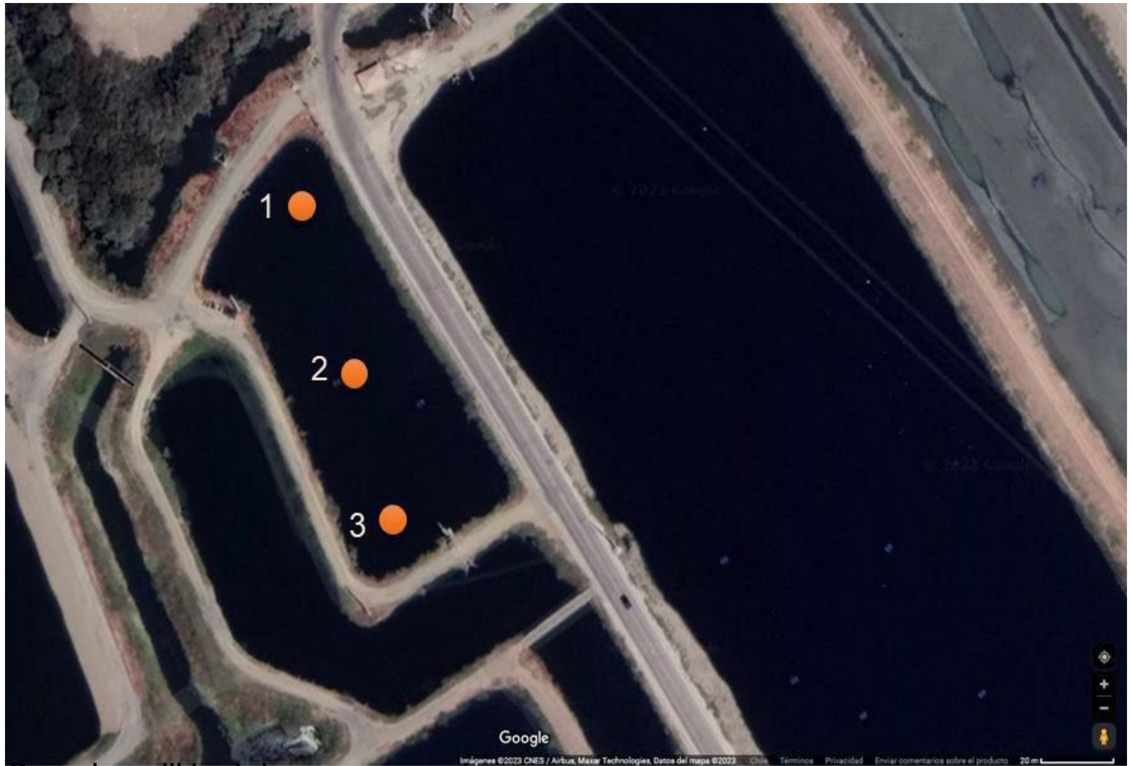
2. Methodology

Pond # 256
2°17'17.2"S 79°52'30.7"W

The pool has water flow and is 1.5 m deep.

2. Methodology

Phytoplankton samples were taken weekly for 14 weeks to assess the abundance and composition of microalgae.



Samples will be taken every week

2. Methodology

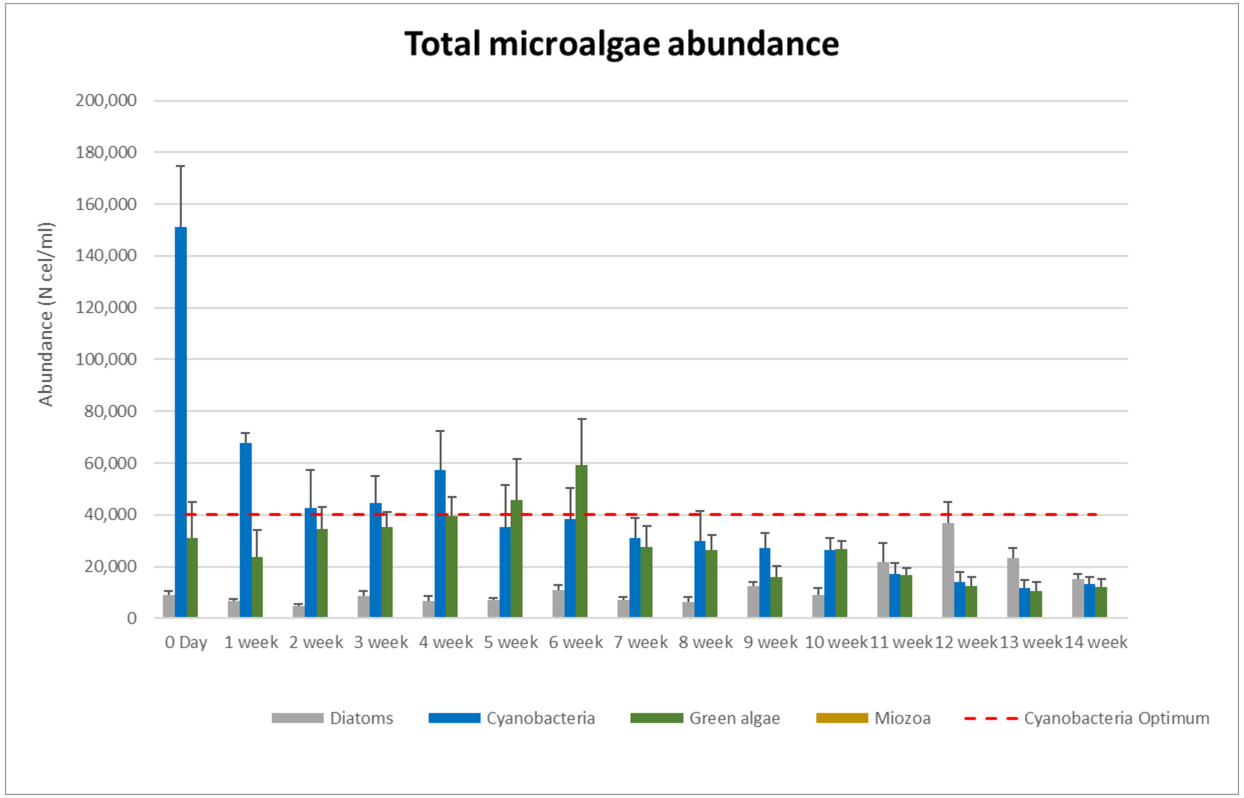
After six weeks, 0.88 g shrimp were placed and the weight and increase were evaluated weekly until harvest.
80,000 shrimp. 20 shrimp/m^2
Samples were taken for histological analysis to show effects on the cells of different shrimp tissues.

Nitrogen was added on Tuesday, December 5 (week 4) and December 12 (week 5) with 6 kilos of Ammonium Nitrate and 6 of Silicate (15k/ha of Ammonium Nitrate, and 15k/ha of Silicate 0.4x15= 6 kilos).
The food has a high concentration of Nitrogen.

It was fertilized with silicate every week.

3. Results

At 14 weeks: 91% Reduction of cyanobacteria.
Cyanobacteria abundance was controlled below the limits established by Cargill in the third week.
58 % Increase of diatoms
67 % Increase of green algae
A shift in species dominance was observed during the ultrasound exposure period.

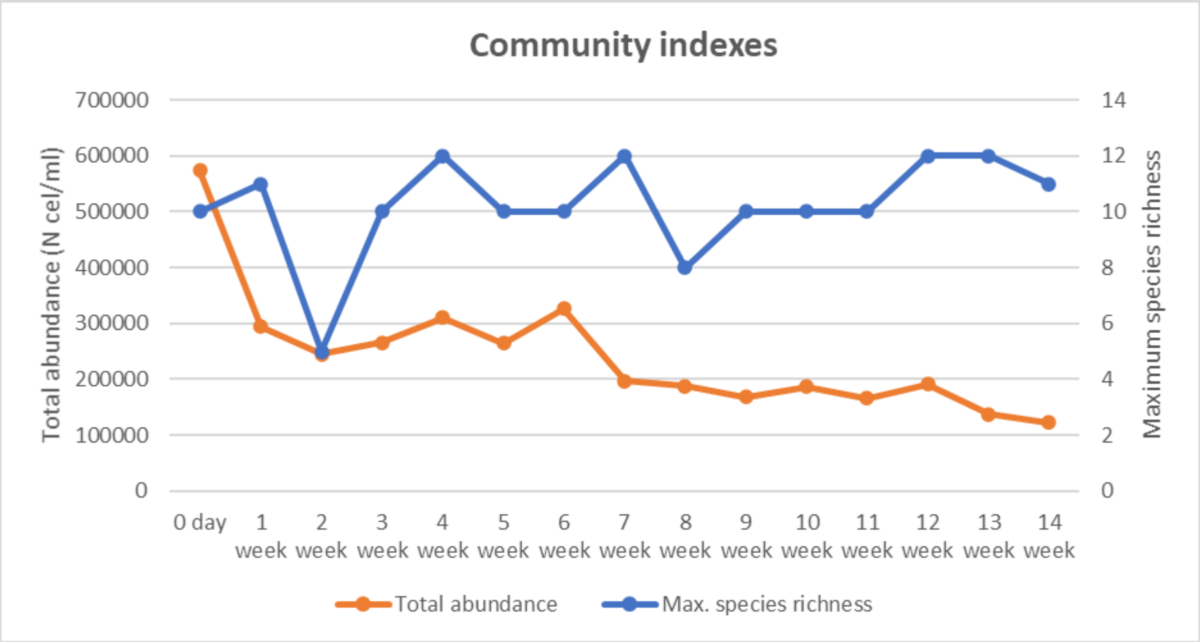


----------- Limit of maximum number of cyanobacteria established by the Cargill Health Department

3. Results

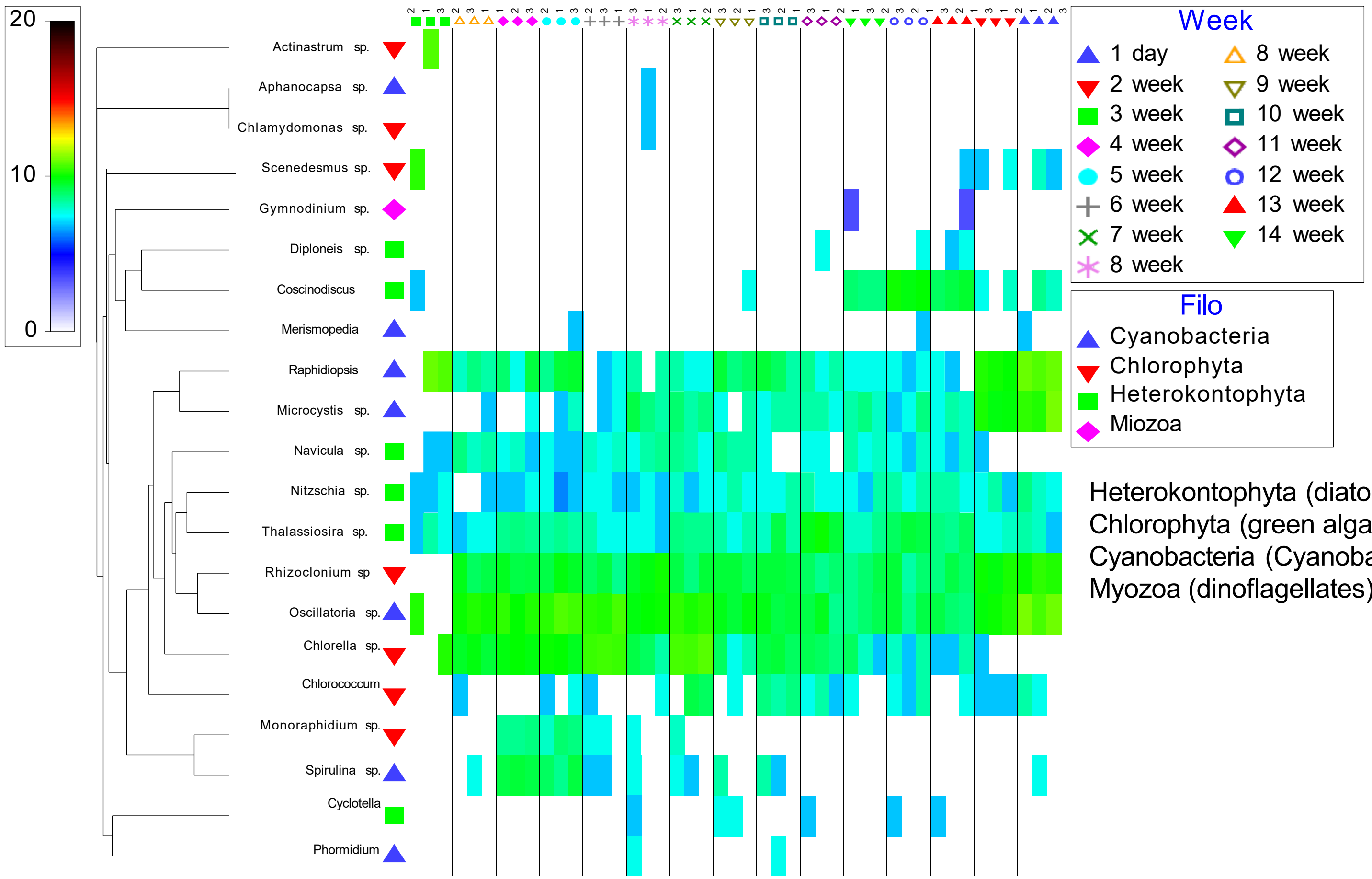
Abundance decreased, and species richness and diversity increased.

Date	Max. species richness	Total abundance	Average Shannon-Weaver diversity H'(loge)
0 day	10	574000	1.60
1 week	11	294000	1.69
2 week	5	245000	0.92
3 week	10	266000	1.90
4 week	12	310500	1.85
5 week	10	264000	1.43
6 week	10	326000	1.71
7 week	12	197000	1.82
8 week	8	188000	1.57
9 week	10	168000	1.98
10 week	10	186000	2.04
11 week	10	166000	1.94
12 week	12	191000	1.96
13 week	12	137030	2.07
14 week	11	122030	2.08
Total	12	3634560	1.77

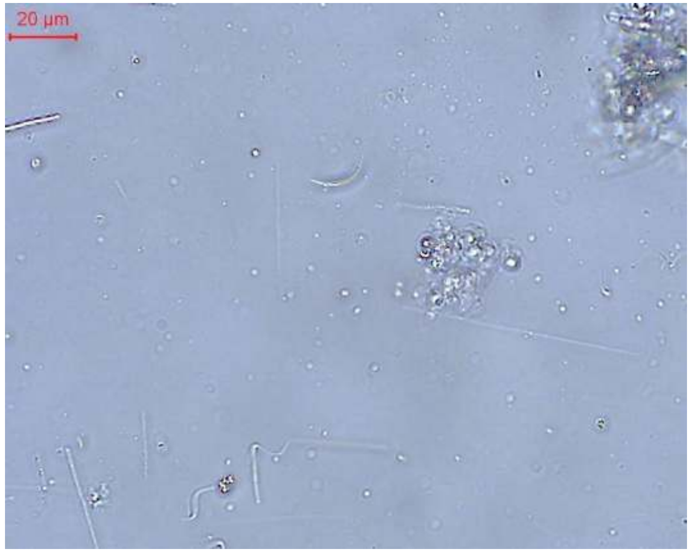


3. Results

Twenty-one species of four phyla and eight classes were found.

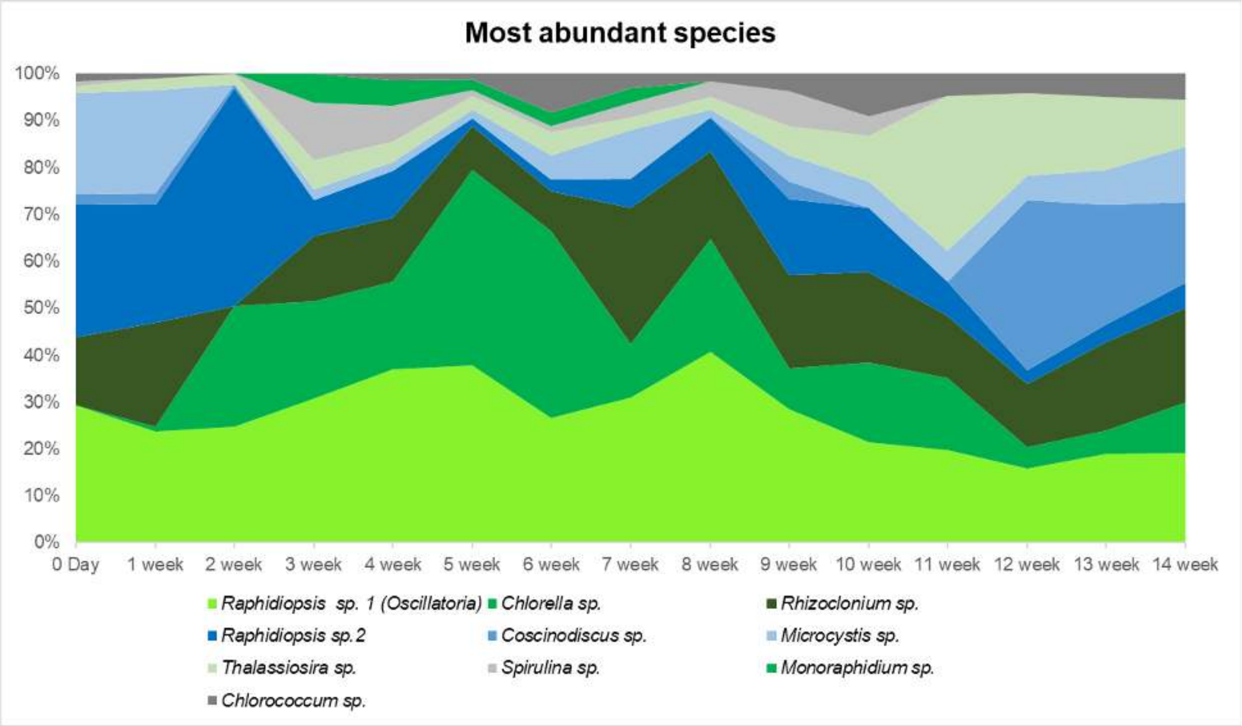


Heterokontophyta (diatoms)
Chlorophyta (green algae)
Cyanobacteria (Cyanobacteria)
Myozoa (dinoflagellates)

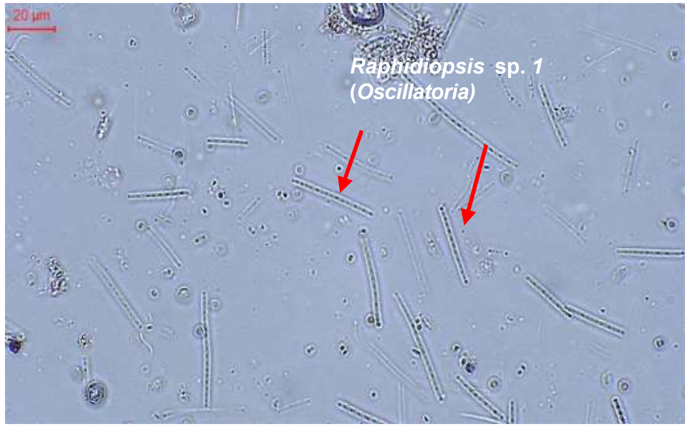


Shadow plot, visual representation of the abundance matrix of the 21 most abundant microalgae species, by site and sampling date. Samples on the x-axis, species on the y-axis. Blanks indicate absence of the species at that site; the intensity of the color scale is linearly proportional to the log(x+1) transformation of the abundance of cells per milliliter. The similarity of the species dendrogram is based on the standardized transformation and the association coefficient. Group means were used for clustering.

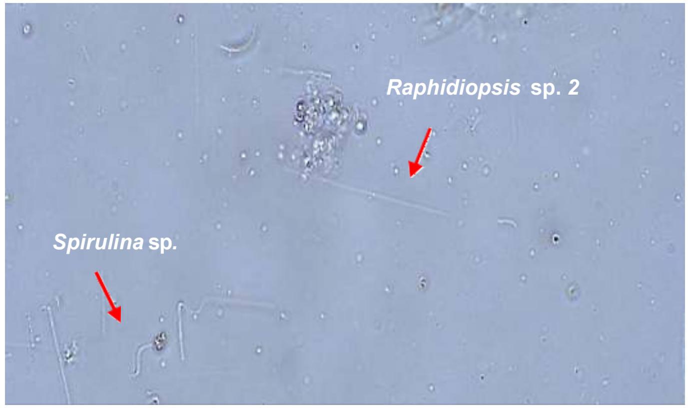
3. Results



Most abundant species
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0 Day
1 week
2 week
3 week
4 week
5 week
6 week
7 week
8 week
9 week
10 week
11 week
12 week
13 week
14 week
Raphidiopsis sp. 1 (Oscillatoria)
Chlorella sp.
Rhizoclonium sp.
Raphidiopsis sp.2
Coscinodiscus sp.
Microcystis sp.
Thalassiosira sp.
Spirulina sp.
Monoraphidium sp.
Chlorococcum sp.



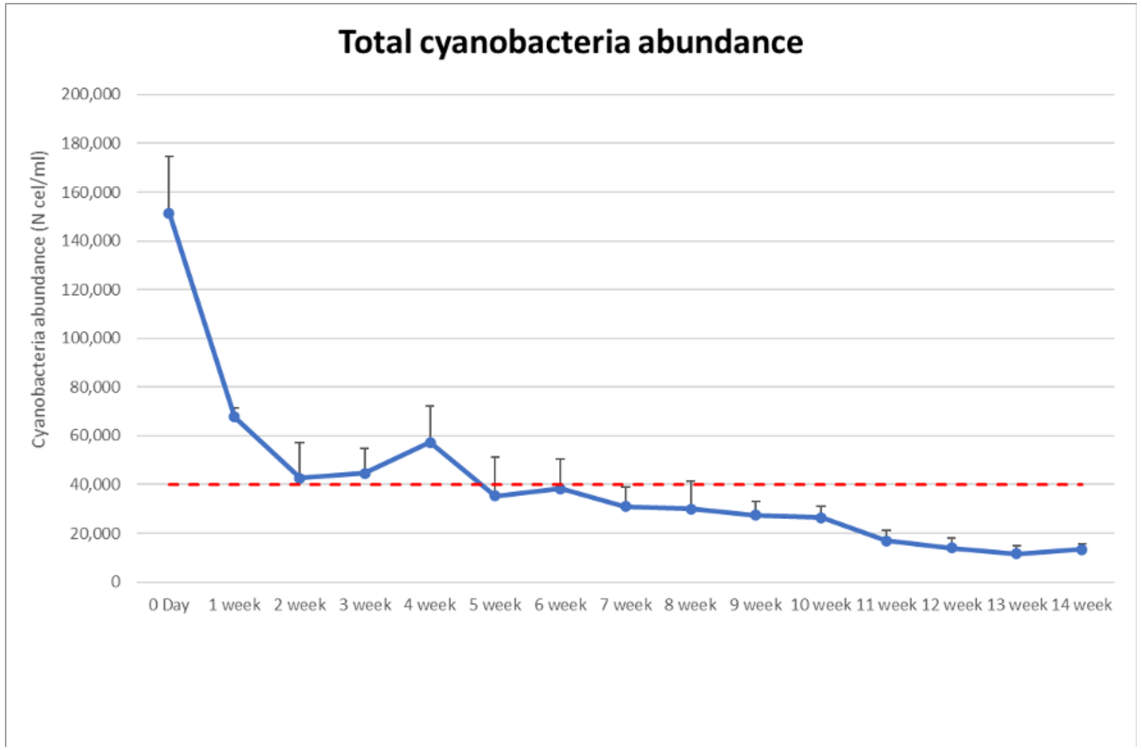
20 µm
Raphidiopsis sp. 1
(Oscillatoria)

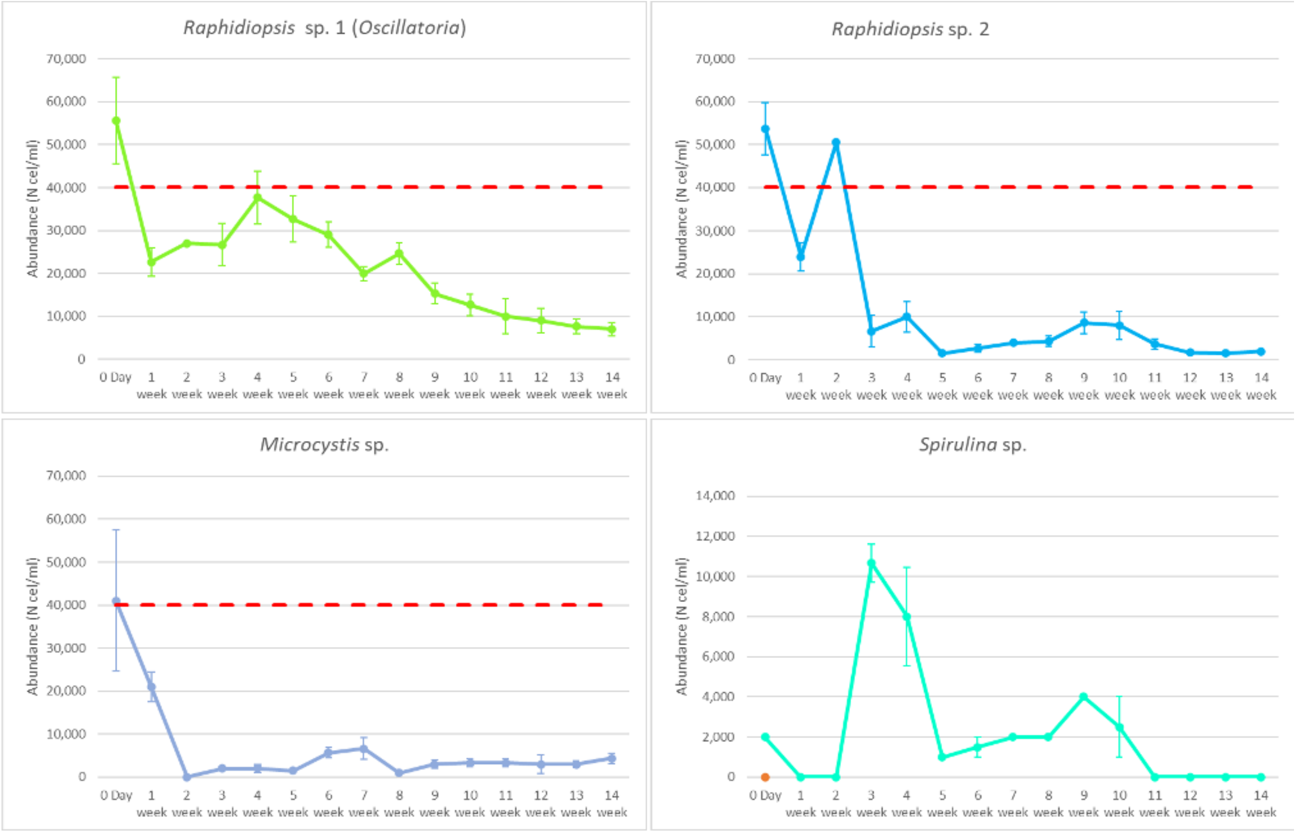


Raphidiopsis sp. 2
Spirulina sp.

20 µm
Coscinodiscus sp.

3. Results

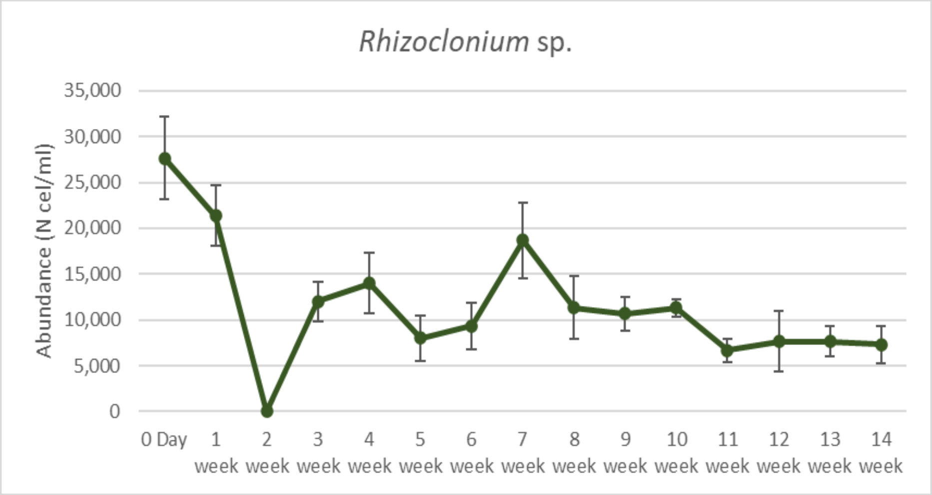


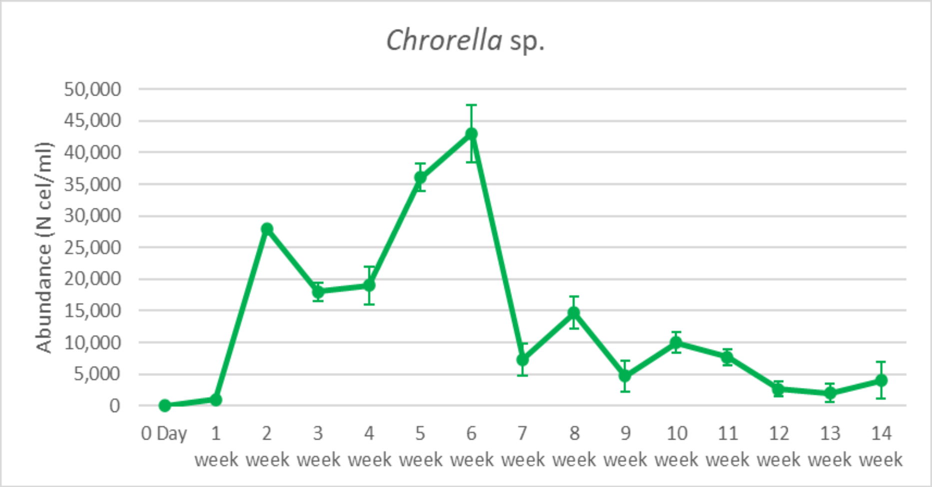


-------- Limit of maximum number of cyanobacteria established by the Cargill Health Department

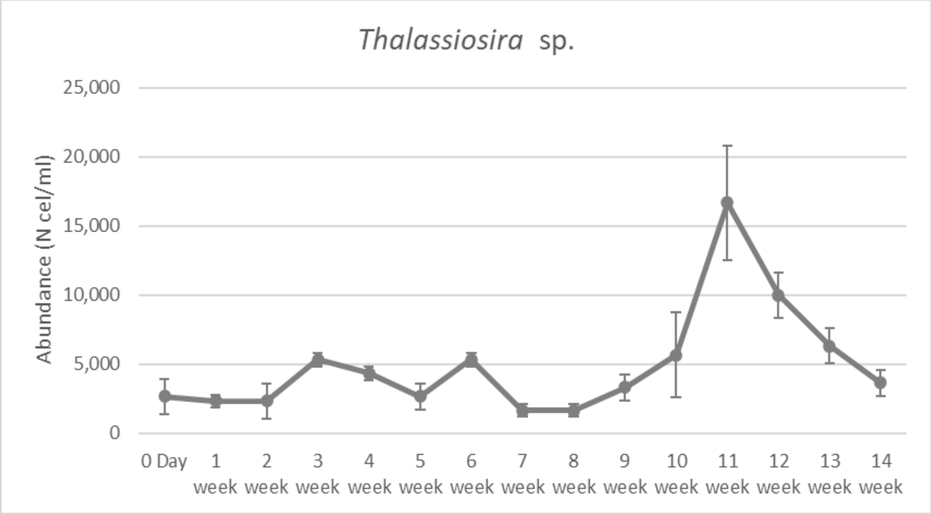
3. Results

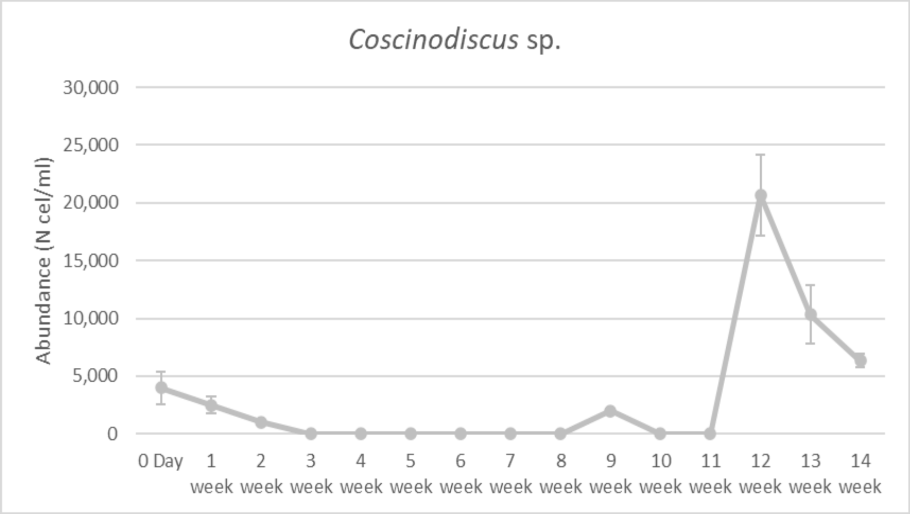
Green algae





Diatoms



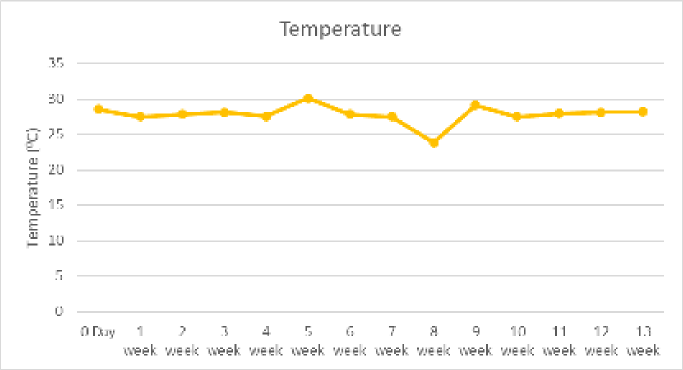


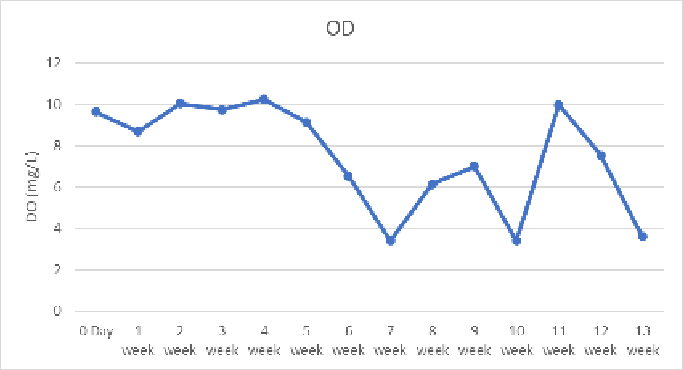
3. Results

Environmental variables

	Temp am	Temp pm	DO am	DO pm	Sechii disk
0 Day	26.5	30.6	4.3	15.0	25
1 week	26.2	28.8	4.1	13.3	30
2 week	26.3	29.4	4.5	15.6	30
3 week	26.8	29.5	3.9	15.6	30
4 week	26.8	28.4	3.9	16.6	30
5 week	27.7	32.6	2.9	15.4	25
6 week	27.1	28.6	3.2	9.9	30
7 week	27.5		3.4		30
8 week	27.1	20.6	3.1	9.2	28.6
9 week	27.7	30.6	3.8	10.2	30
10 week	27.5		3.4		30
11 week	27.5	28.5	3.4	16.6	30
12 week	27.5	28.8	3.4	11.7	30
13 week	27.5	28.9	3.6		30
14 week					30
Average	**27.1**	**28.8**	**3.6**	**13.6**	**29.2**
Desvest	**0.5**	**2.8**	**0.5**	**2.8**	**1.8**
Max	**27.7**	**32.6**	**4.5**	**16.6**	**30.0**
Min	**26.2**	**20.6**	**2.9**	**9.2**	**25.0**

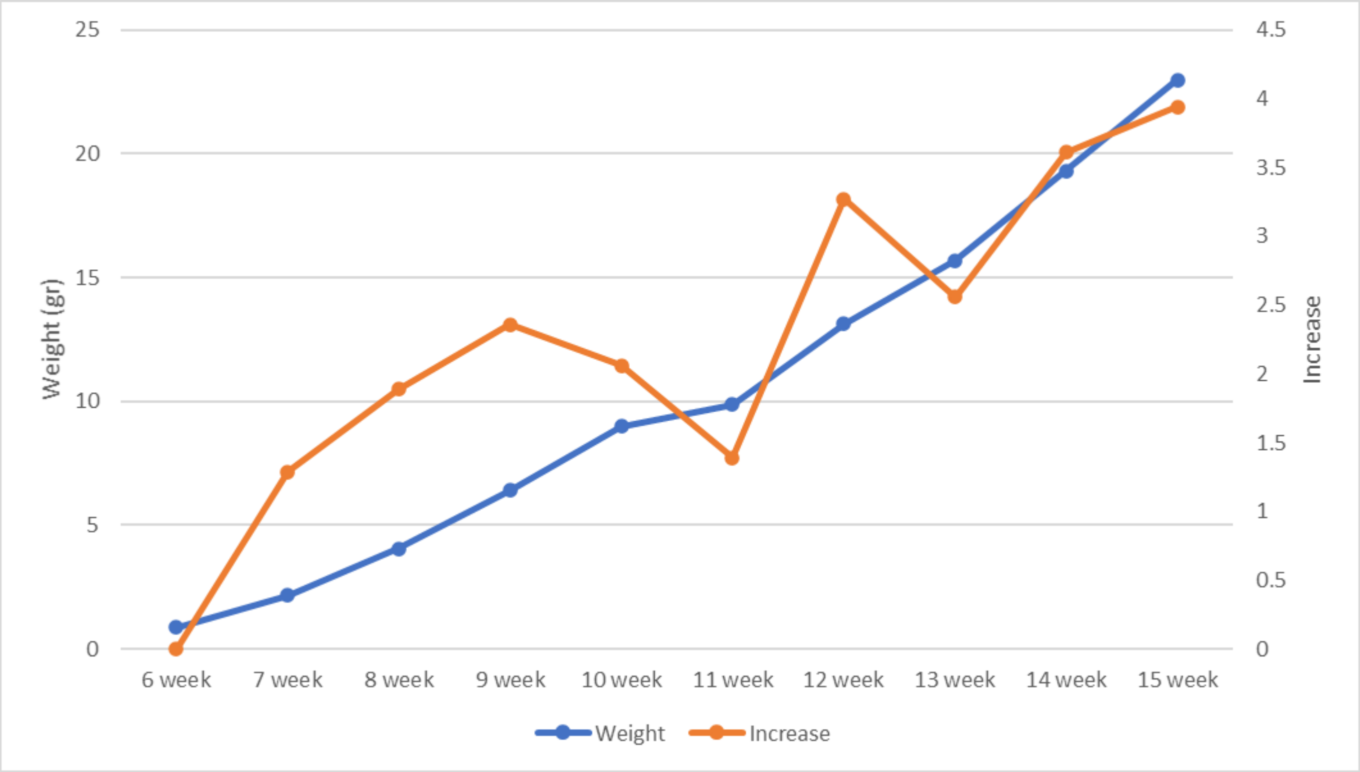
Average environmental variables





3. Results

Weight and increase of shrimp in the pool with ultrasound

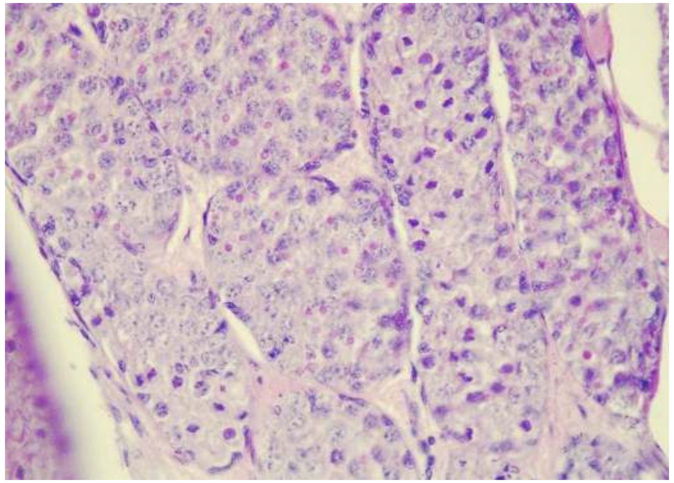


20 animals/m^2 82% survival

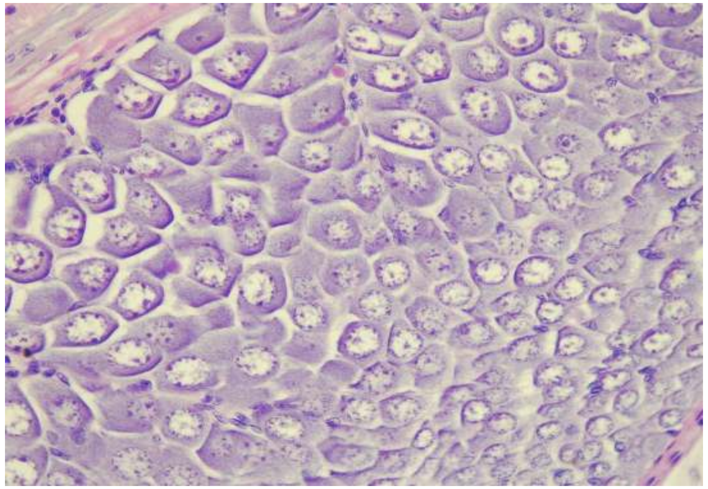
Growth 2.24 gr

3. Results

Gonad

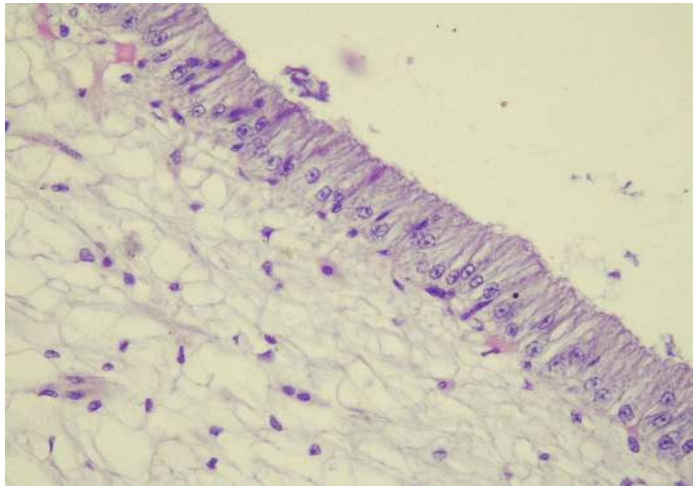


(40X) Male. Immature gonad.



(40X) Female. Immature gonad.

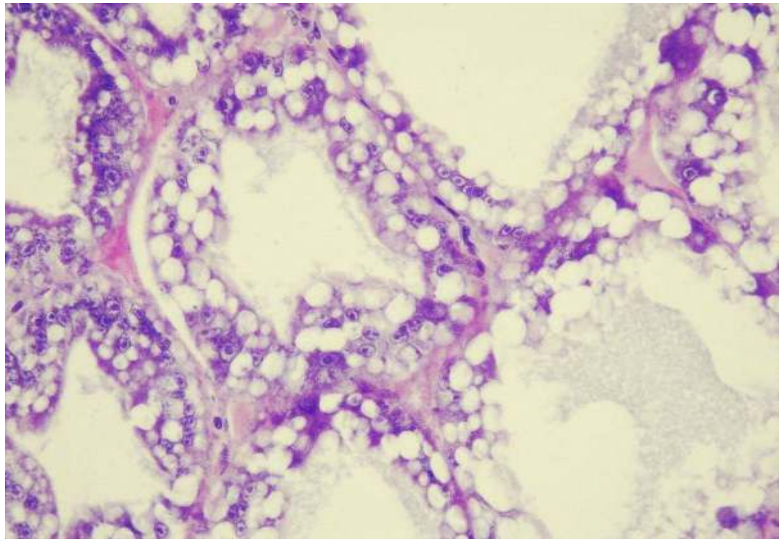
Stomach



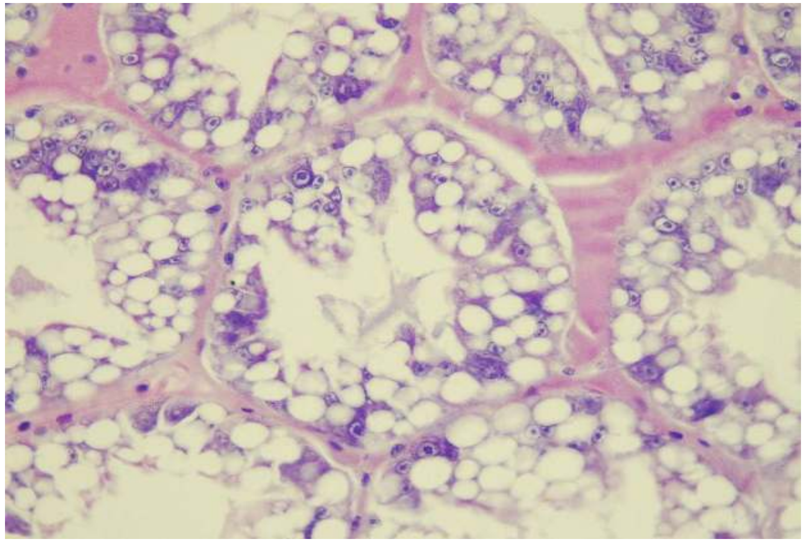
(40X) Normally structured stomach epithelium.

3. Results

Hepatopancreas

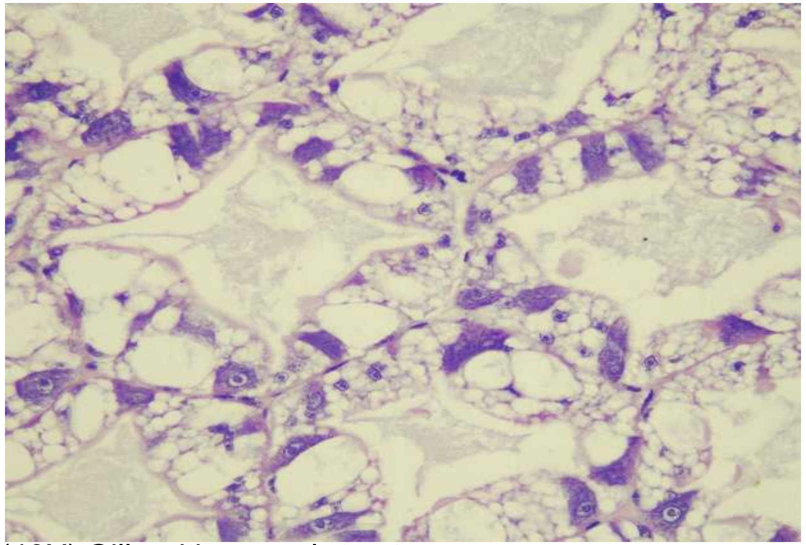


(40X) Hepatopancreas with normal structure and abundant reserve bodies.



(40X) Hepatopancreas with normal structure and abundant reserve bodies.

Gills



(40X) Gills with normal structure.

4. Conclusions

1. Cyanobacteria were 91% eliminated at the end of the study period. Four different species of cyanobacteria were recorded. The genus Raphidiopsis was the most abundant and was controlled in the fourth week of ultrasound exposure.
2. The abundance of green algae was controlled by 61% at 14 weeks of exposure.
3. Diatoms, mainly Thalassiosira sp. and Navicula sp. increased their abundance by 70% at 14 weeks of exposure.
4. A shift in species dominance was observed during the ultrasound exposure period. In weeks 5 to 7 and during the last week of sampling (week 14) green algae dominated the phytoplankton community. In weeks 11 to 13 diatoms dominated.
5. The abundance of microalgae, mainly cyanobacteria, decreased, but species richness and diversity increased. Ultrasound exposure did not affect shrimp survival or growth in weight.
6. Neither did the structure and morphology of the cells of the gonadal tissues, stomach, hepatopancreas and gills.

Wateriq Technologies, LLC

WaterIQ Technologies, LLC se formó para ser el principal proveedor de remediación de algas utilizando la tecnología ultrasónica patentada de la compañía integrada con sistemas de monitoreo remoto de la calidad del agua.

La compañía ha invertido millones de dólares para desarrollar el Pulsar 4400 líder en la industria que ha demostrado que puede controlar especies más difíciles de cianobacterias como *Oscillatoria, Raphidiopsis* y *Lyngbya*.

A continuación se muestra un antes y una foto de un estanque afectado por *Lyngbya*.

WaterIQ Technologies ha reunido un equipo de científicos experimentados para ayudar a nuestros clientes a controlar las cianobacterias

GeorgeHutchinson – Director Técnico: Ingeniero químico por Carolina del Sur: 23 años de experiencia en British Petroleum; fundador de Algae Control US y Sonic Solutions Algae Control. Ha vendido más de 10 millones de dólares en equipos de remediación de algas y ha desarrollado una red mundial de distribuidores antes de unirse a WaterIQ Technologies. También ha desarrollado el conjunto de frecuencias ultrasónicas 4.400 para el nuevo Pulsar 4400.

Jordan Meissner– Vicepresidente de Ventas Globales - Licenciado en Empresariales por la Universidad Estatal de Illinois. Jordan cuenta con 10 años de experiencia en la gestión de lagos y estanques. Antes de incorporarse a WaterIQ, fue director regional de Solitude Lake Management, la mayor empresa de gestión de estanques del mundo.

Dra.Viviana Almanza Marroquin – Directora de Mercado para Sudamérica - La Dra. Almanza es doctora en Ciencias Ambientales, con especialización en microalgas y taxonomía del fitoplancton. Es una de las principales expertas en ecología de cianobacterias y otras algas formadoras de floraciones en Sudamérica. La Dra. Almanza Marroquín ha publicado numerosos trabajos sobre el impacto de las cianobacterias en Sudamérica.

Dr. EnriqueMora Heredia - Director de Mercado - América Central- El Dr. Mora es Doctor en Ecología tropical por la Universidad de Veracruz, con especialización en ecología acuática. El Dr. Mora es considerado uno de los principales expertos en el tratamiento de cianobacterias y otras algas nocivas en masas de agua de América Latina.

RickClark – Director de Asuntos Medioambientales y Normativos- Rick tiene un máster en Biología por la Universidad del Sur de Alabama. Trabajó para el Departamento de Salud de Florida, donde formó parte del grupo de trabajo estatal sobre floraciones de algas nocivas. Rick se encarga de gestionar un grupo de concesionarios y de trabajar con municipios, condados y estados asegurando contratos para controlar las floraciones de cianobacterias.