Impact of climate change on shrimp fisheries : the case of Ambaro Bay, North West Coast of Madagascar

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Introduction

A **sequential shrimp fishery :** with a traditional segment in estuaries / coastal waters / in mangrove channels, and an industrial segment operating in trawling grounds.

Continuous development of small-scale shrimp fishery (SSSF) but no comprehensive monitoring / data collection.

Studies focused only the NW Madagascar, specifically the Ambaro Bay

Drastic drop of shrimp catch in 2005, despite various measures (thorough management then reduction of industrial fishing effort), catches haven't yet recovered.

Potential role of climate change on shrimp stock diminution to be investigated

1. Background knowledge

1.1 Description of the study area : Ambaro Bay

1.2 Description of the shrimp species

1.2.1 Bathymetric distribution

1.2.2 Life cycle

1.2.3 Abundance

1.1 Description of the study area : Ambaro Bay

North West Coast of Madagascar

between 13°28'S / 48°30'E, 12°29'S / 48°40'E and 13°28'S / 49°00'E.

Main parameters defining the estuary-sea system : S‰, sea level, and turbidity.

Semi diurnal tides with an amplitude > 4 m.

Climate of Sambirano region : two seasons delineated by rainfall and rivers flow inducing a significant decrease in S‰ (5 to 20 ‰ in February and 30 – 35 ‰ in November).

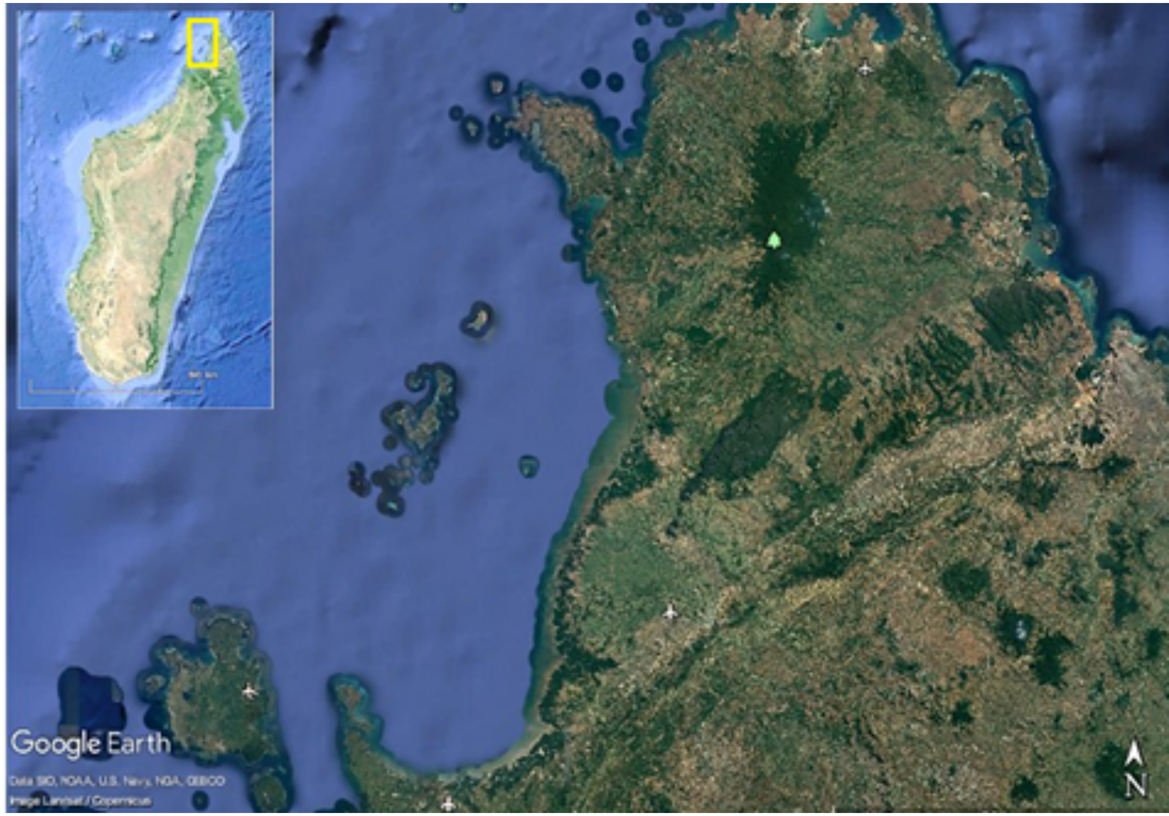

Fig.1 The study area

1.2 Description of the shrimp species

About 34 shrimp species of commercial interest recorded but **only the 6 shallow water peneid shrimp exploited**

Species	Commercial names
Fenneropenaeus indicus	White - **the most abundant**
Penaeus semisulcatus	Tiger, flower, calendar or brown
Penaeus japonicus	tiger
Penaeus monodon	Tiger, camaron or king
Metapenaeus monoceros	Pink or brown
Metapenaeus stebbingi	Brown

Table 1. The shallow water shrimp species exploited in Madagascar

Because of its relative abundance in catches, ***F. indicus* is the most studied species**.

1.2 Description of the shrimp species

1.2.1 Bathymetric distribution of the 3 main species exploited off the Western coasts of Madagascar: *F. indicus, M. Monoceros and P. semisulcatus. (*Rafalimanana (2003)

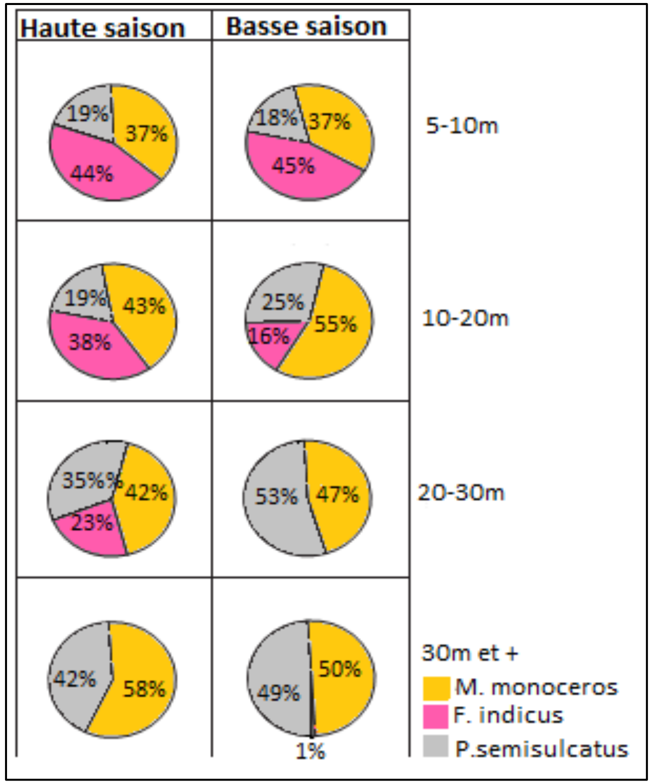

Fig.2 Mean species composition of shrimp catch per season and per bathymetric stratum of the 3 main shrimp species exploited off the western coast of Madagascar. High season: December to May: Low season : June to November (source: Rafalimanana, 2003)

1.2 Description of the shrimp species

1.2.2 Life cycle:

Shrimps are **very prolific** (can lay 500 000 to 1 000 000 eggs). ➔the **resource is robust** so that reproduction potential is not very sensitive to fishing pressure unless an over exploitation of the recruitment happens

Shrimp are **amphibiotic**, larvae survival is highly dependent to environmental conditions, *they are the most sensitive stages to climate change*.

Environmental conditions (S‰, T°C, nutrients) ➔ bathymetric and spatial distribution, larvae and juvenile survival, growth and reproduction; and their availability to each fishery type.

1.2 Description of the shrimp species

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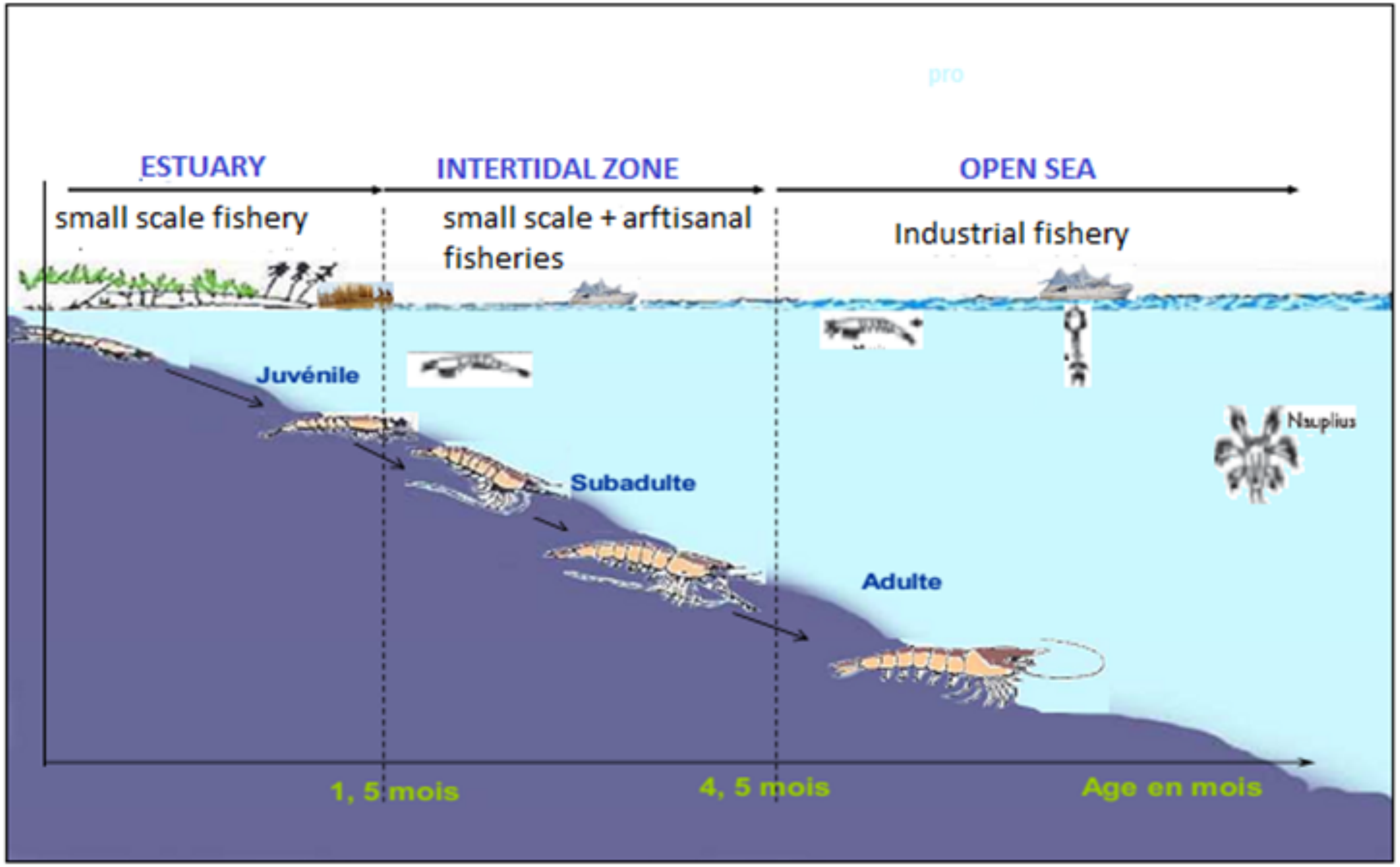

Fig.3 Migration scheme of *Fenneropenaeus indicus* in Ambaro Bay (source: Razafindrainibe H., adapted from Rafalimanana T. 2003 and Rasolofo V.M., 2011)

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1.2 Description of the shrimp species

1.2.3 Abundance (stock availability) :

The **evolution of catch** can be considered **as an index of local shrimp abundance** in absence of appropriate periodic surveys. However, small scale shrimp fishery catches are hardly monitored and reported in national statistics, compared to the industrial fishery.

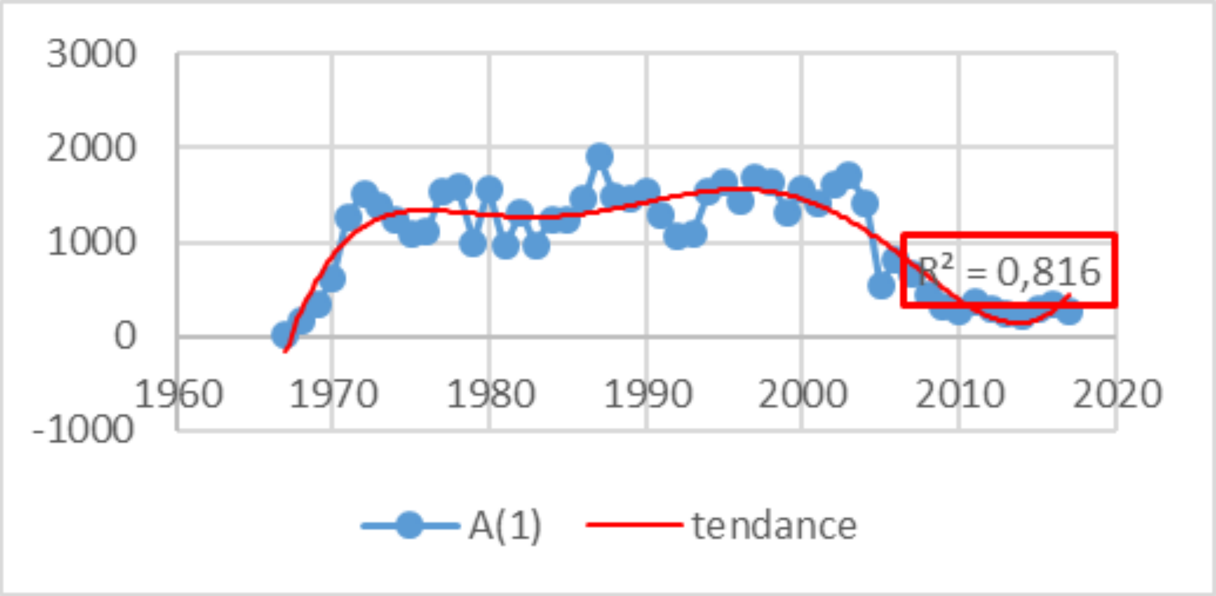

Fig. 4 Evolution of industrial shrimp fishery catch (Tons) in the management area A (Ambaro Bay, Tsimipaika Bay) from 1967 to 2017 (source: Ministry in charge of Fisheries; 2018)

2. The use case

2.1. Objective and hypothesis

2.2 Method

2.1 Main objective et hypothesis

2.1.1 Main objective

A better understanding of why shrimp catches have drastically dropped and haven't yet recovered despite all measures taken towards fishing efforts and gear

2.1.2 Hypothesis

- H1-SSSF targets juvenile phase with traditional fishing gears in mangrove and estuaries AND adults in deeper water, with "new" net-type fishing gears competing with industrial trawlers, and overall catch is remaining stable;

H2-Key environmental parameters have significantly changed, due to climate change, inducing a decrease in resource availability by an increase in natural mortality and or migration to other area.

2.2 Methods

Key parameters to investigate are:

Parameters	Observation	source	Method of analysis
Coastal salinity gradient and seasonality	no in situ time series no available satellite data		
Rainfall input (catchment basin) + river flow	Only mean rainfall for a long period available Not available	Met Office	Data pre analysed
Sediment flow into sea water		Satellite images with EOS Landviewer, - Landsat 5™, 7 and 8 - Sentinel-2 L2A - Sentinel-2 L1C https://eos.com/landviewer/	https://processing.eos.com

2.2 Methods (cont.)

Sea surface temperature		Satellite date: Noaa-sst-wio time series	BILKO software
Chlorophyll-a	Analysis of phyto plankton: peaks, blooms, timing and location	Satellite data	BILKO software
Sea level	Will be a proxy as the area is not on the satellite track	Satellite data	(by Met Office Team)
Coastal currents	Influence of open sea currents are limited due to the site morphology, bathymetry …	Satellite images same as for sediment flow	

3. Results

3.1 Sediment flow

3.2

3.1 Sediment flow

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Supposed to be at its maximum during rainy season when rainfalls induce a high river flow. This helps to define the area impacted by fresh water, thus the gradient of salinity. Unfortunately, this cannot provide salinity value

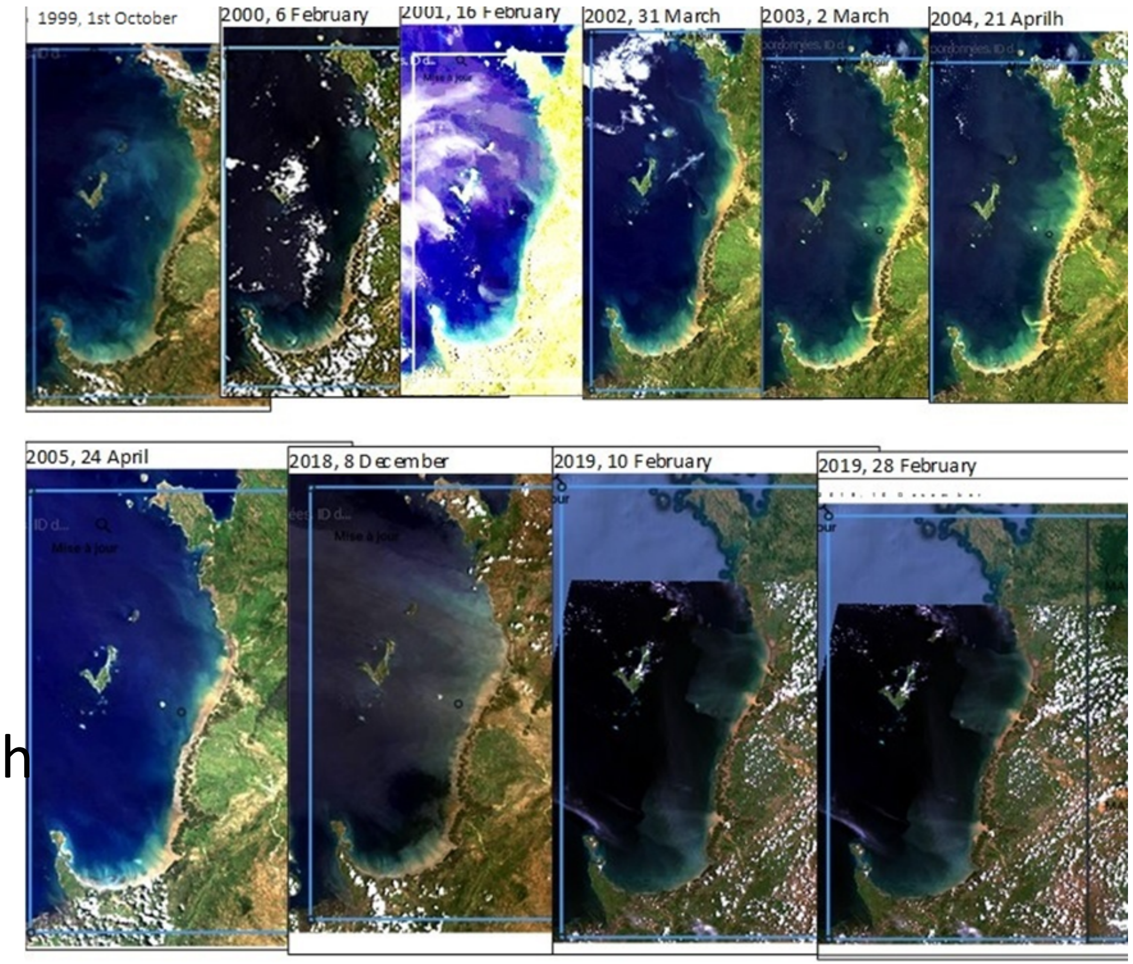

Fig.4 Interannual variation of sediment flow extent in Ambaro Bay during rainy season from 1999 yo 2005 and l, end 2018-early 2019 (source: Landsat and Sentinel 2 through EOS: https://eos.com/landviewer/)

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3.1 Sediment flow (cont.)

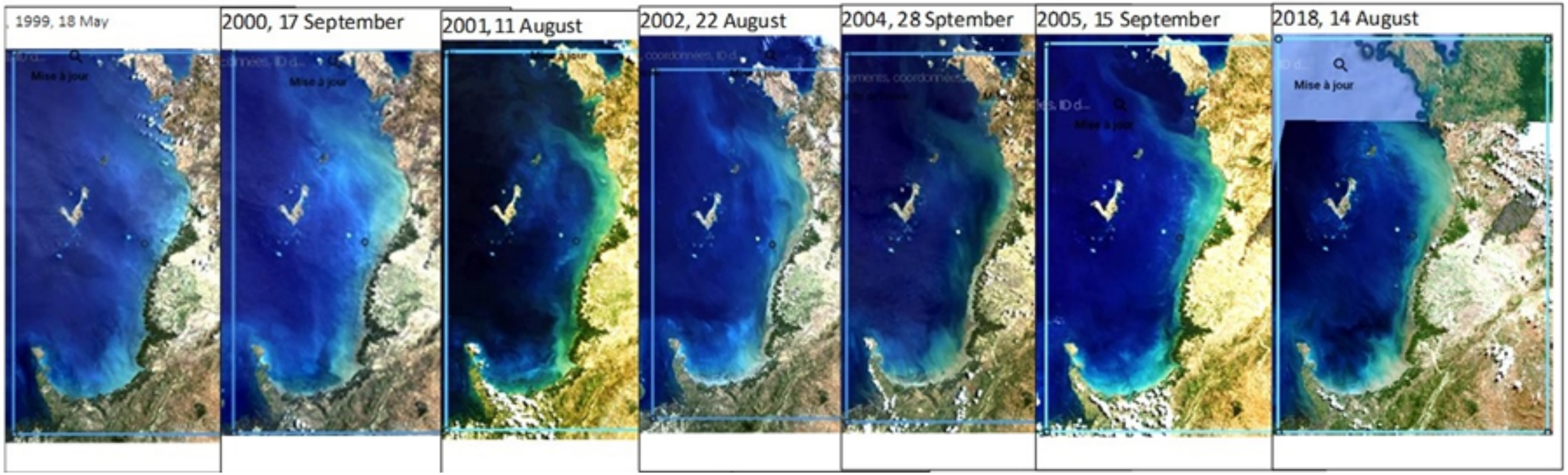

Fig.5 Interannual variation of sediment flow extent in Ambaro Bay during det season from 1999 to 2005 and 2018 2019 (source: Landsat and Sentinel 2 through EOS: https://eos.com/landviewer/)

no or low sediment flow from land, except in 2018, but overall direction of near coastal currents during dry season. Might be of importance for early pelagic larval stages before migration into the estuaries and mangroves. Coastal current remains close to the coastline. In the bottom of the bay, the salinity gradient tends to remain in place.,

3.2 Pending analysis

3.2.1 Rainfall data will finally be processed by the Met Office. The processing shoud locate anomalies ans change in seasonality.

3.2.2 Chlorophyll a: will be analysed with BILKO software, selecting as much as possible the synchronic data with the above satellite imagery, to help interpreting these later. Considering the amount of data, the completion of the task is delayed (the processing is underway)..

3.2.3 Sea Surface Temperature: is in the same case as for chlorophyll a..

4. Conclusion and recommendation

- This first result help **orienting field work on shrimp larvae dispersal and survival** in this area.
- As in situ data are critically missing, the **satellite data are of invaluable** substitute, also snapshot images make easier track of change.
- As **no salinity measurement is available for the mom**ent, it will not be possible to assess to which extent it might have impacted the species (larval stages) survival.
- So, the **SST will apparently be the main parameter to analyse** on this use case

4. Conclusion and recommendation (cont.)

- Data analysis will be continued until completion. Some of the use cases are complementary to this one: mangroves of the Ambaro Bay, the Met Office use cases on the North West Madagascar. When all of them will completed, a joint analysis should be organised.

- If satellite derived date on sea surface salinity (SSS) of the Madagascar water can be and made available.

- Ways and or means to make sustainable the acquisition of satellite images and data should be prospected. They do exist but access is expensive.

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