Tsunami Impacts on Shallow Groundwater and Associated Water Supply on the East Coast of Sri Lanka

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Objectives

1st phase:

- To support and evaluate the immediate relief efforts aimed at rehabilitating the decentralized water supply from groundwater
- Assess the immediate and intermediate impacts of the tsunami on shallow wells based on a monitoring program in three representative areas

2nd phase:

- To support the efforts of re-establishing a functioning water supply in the affected areas and to ensure that viable solutions are sought for water supply based on groundwater in the longer term

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Components

1st phase:

- Dialog with NGOs and other actors on well cleaning and well monitoring
- Producing and disseminating recommendations and guidelines on well cleaning and GW use
- Monitoring GW conditions and water quality

2nd phase:

- Continued GW monitoring
- Detailed field studies of saltwater intrusion and modelling
- Assessment of risk areas and groundwater potential for water supply
- Devise sustainable and adaptable solutions
- Capacity building and awareness raising

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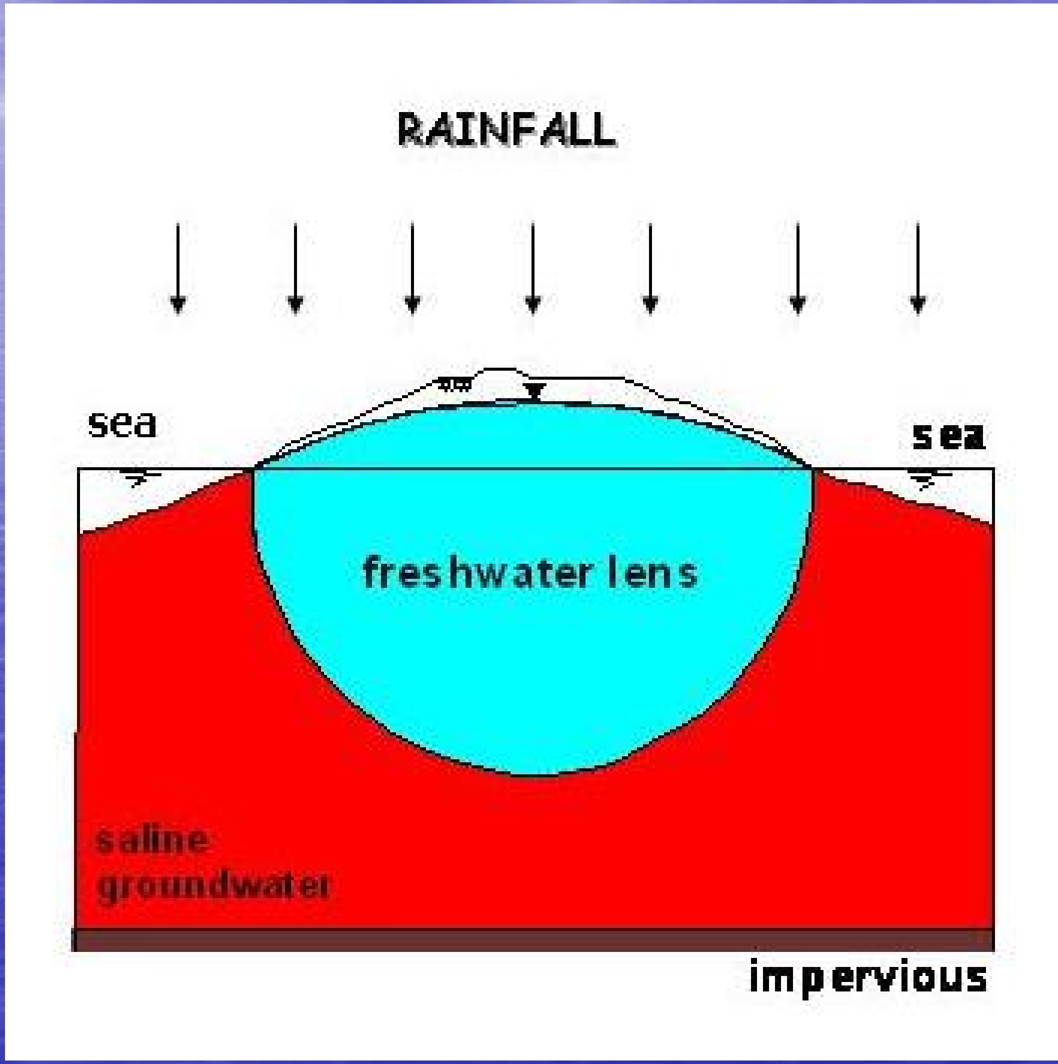
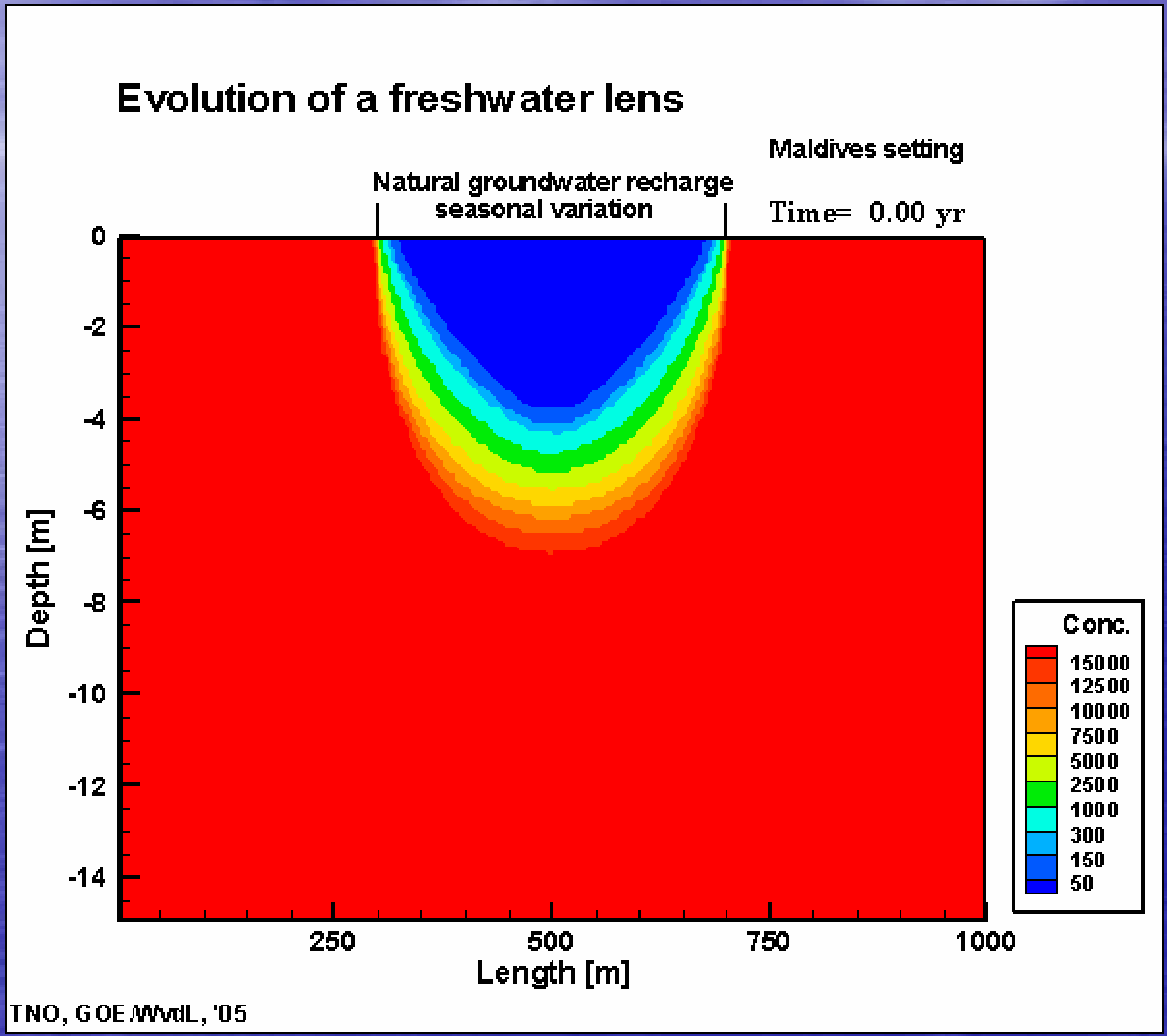
An island is surrounded by salt water

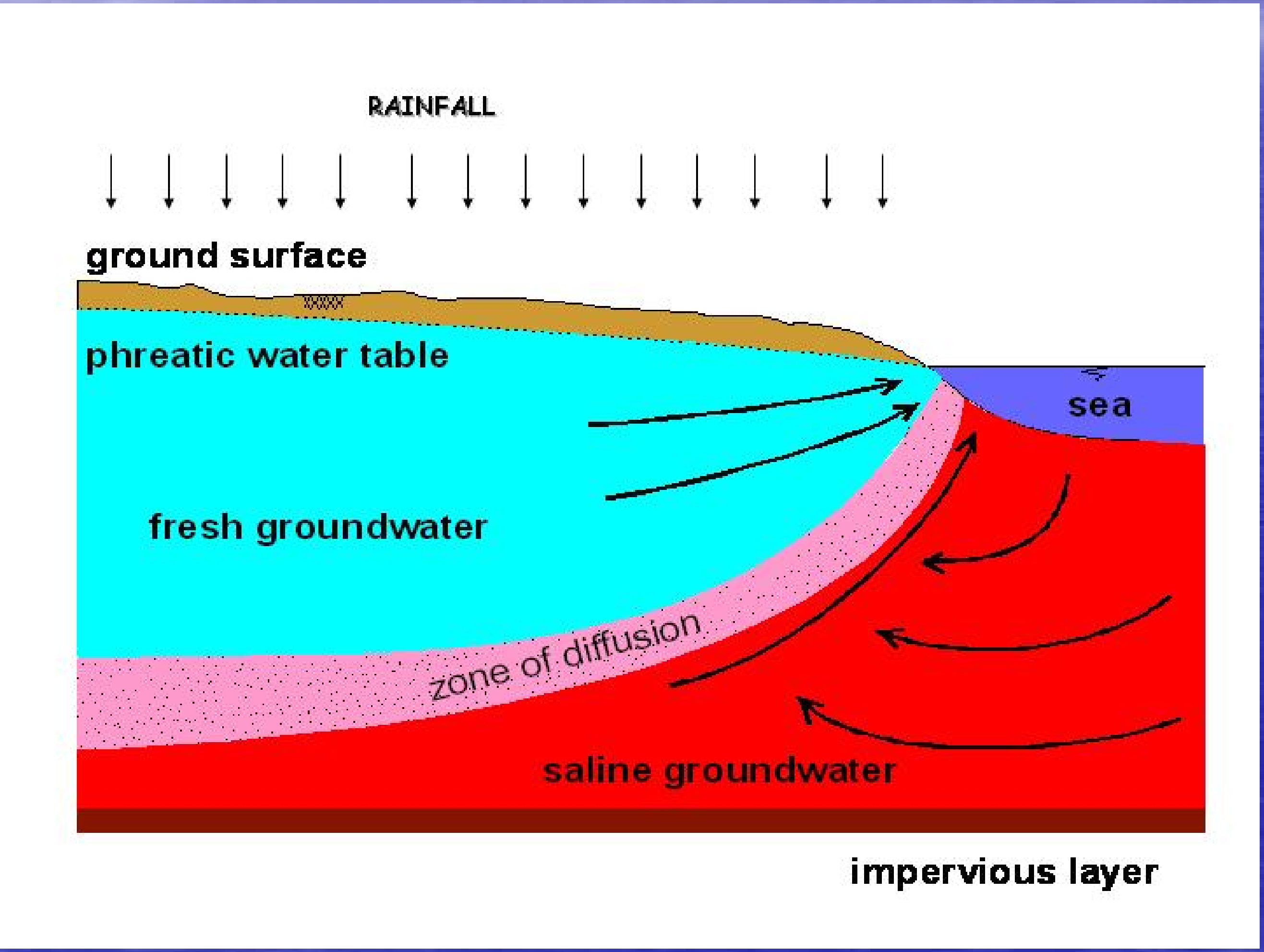


Rainwater sustains the freshwater lens

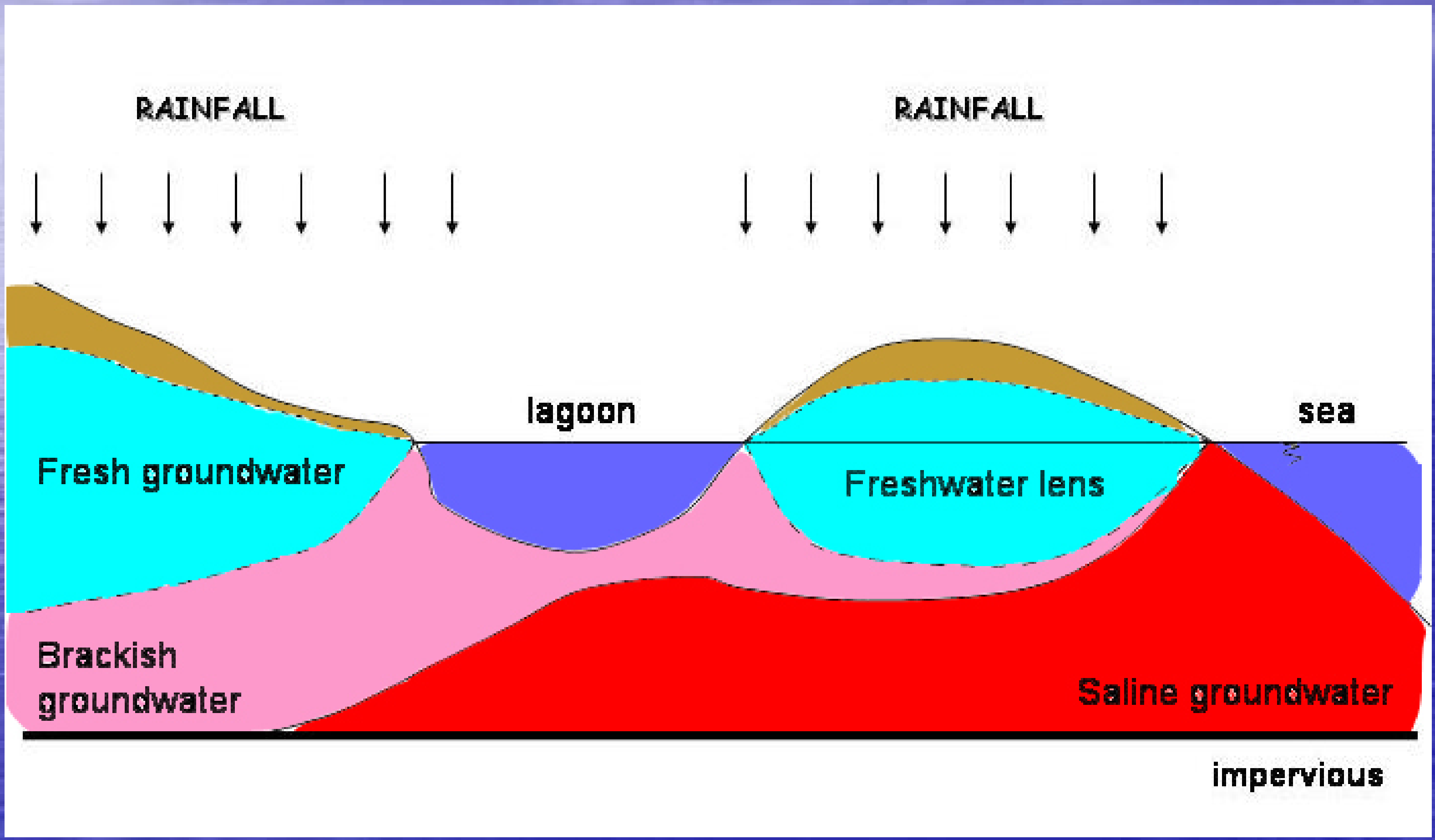


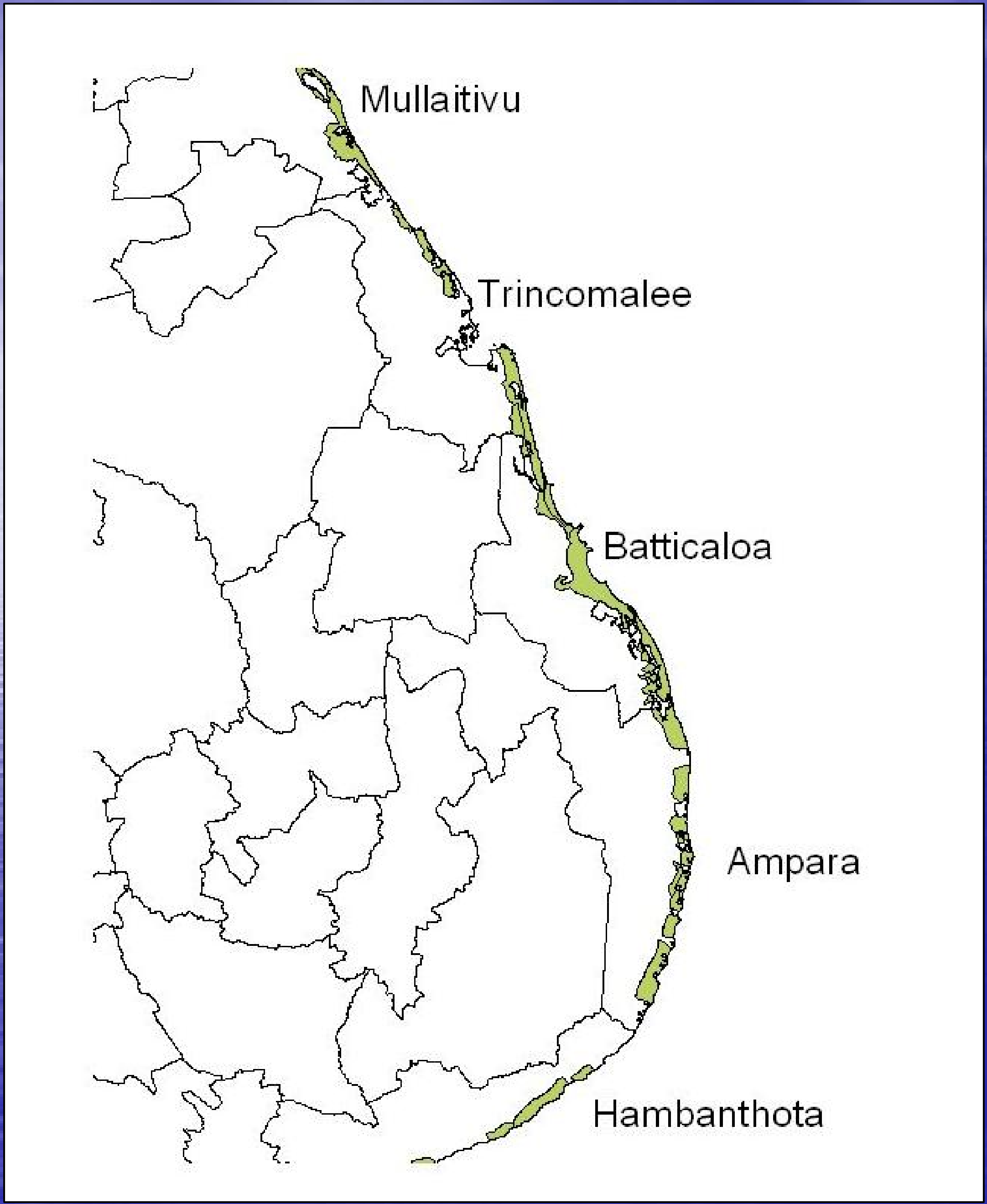
Source: IGRAC

Constant balance between salt and freshwater



A coastal lagoon is an intermediate case





Extent of coastal aquifers on the East coast

The coastal aquifers are good water sources

- On land strips, groundwater is the only source
- Generally replenished with good and sufficient rainwater
- No natural groundwater contamination, like fluoride or arsenic
- High-yielding, shallow wells

→ Water on-demand, on-the-spot

- However, potential threat from tsunami, saltwater intrusion and other pollution

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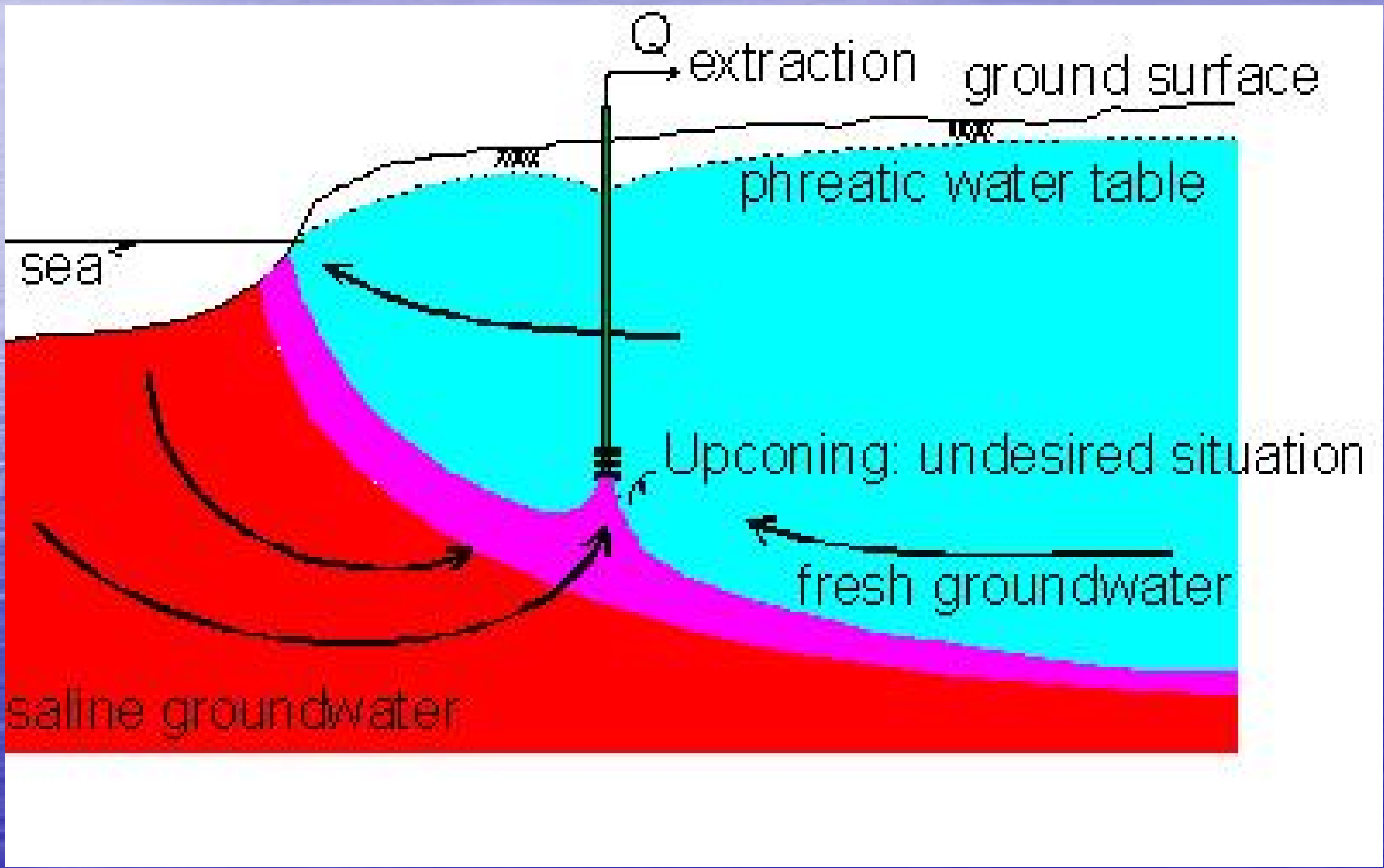
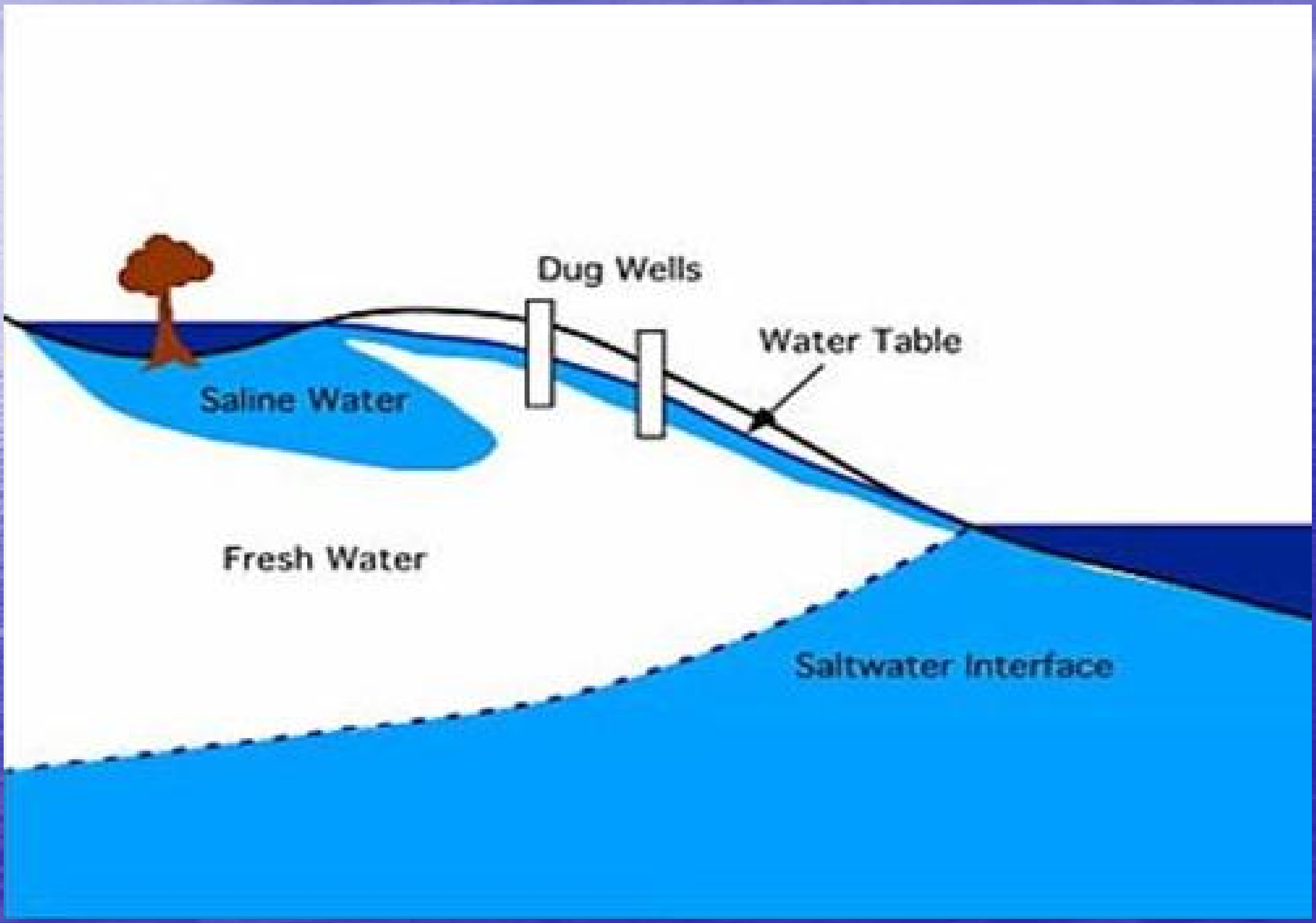
Pumping and cleaning of wells in the coastal auifers



Saltwater effects of the tsunami



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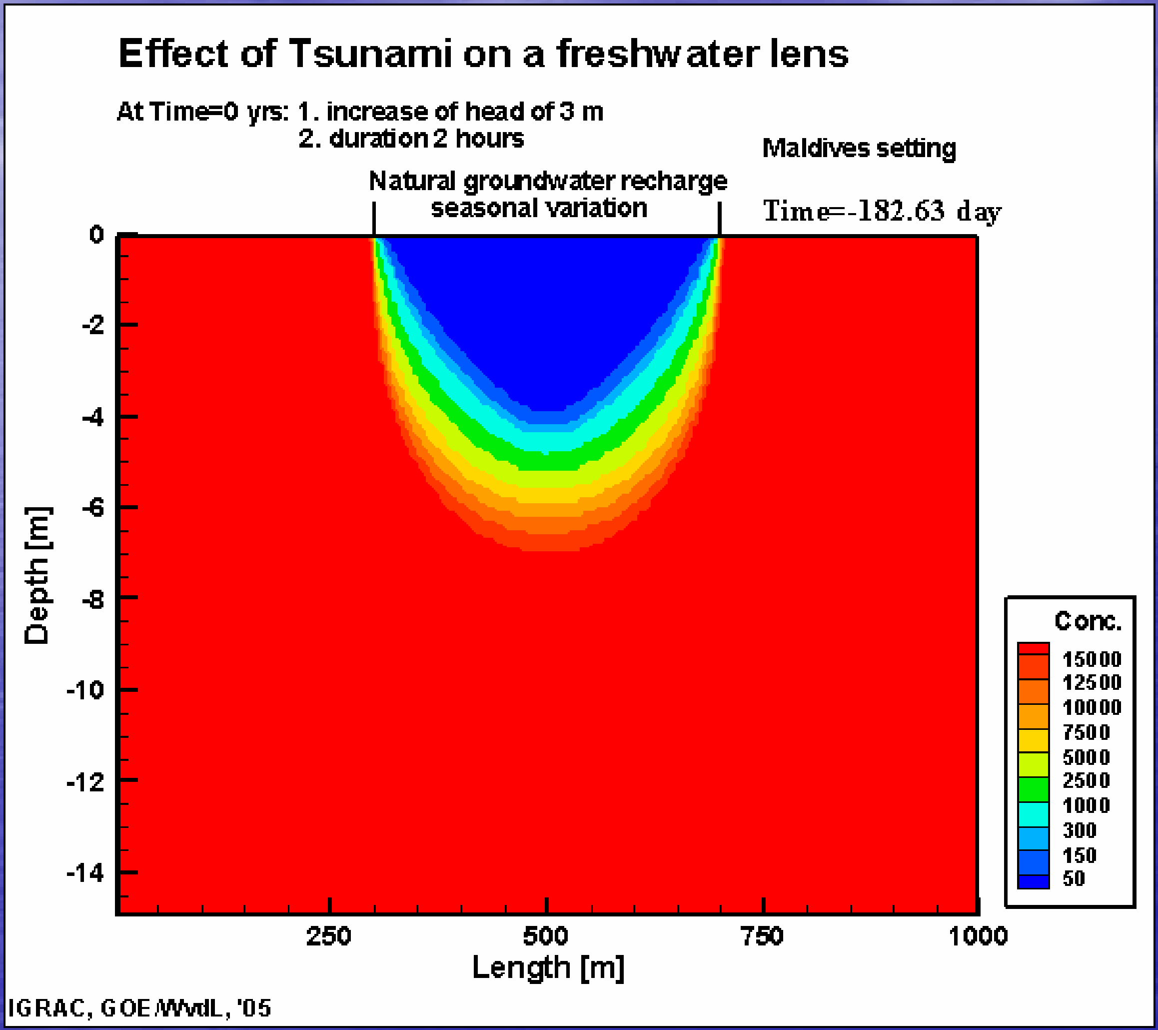
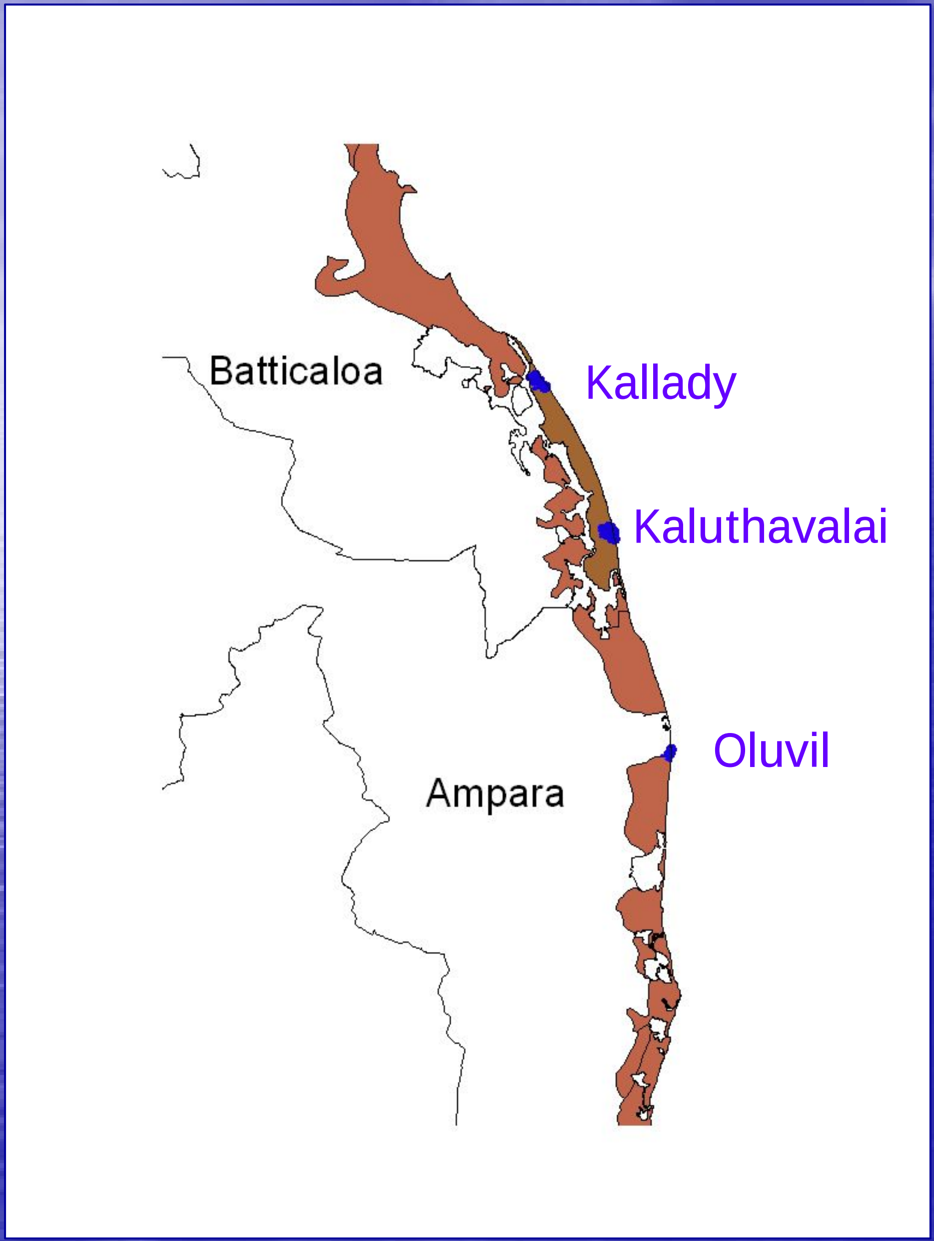
The tsunami disturbed the natural system



Source: IGRAC

Study areas



Monitoring program

- 150 wells monitored, approx. 50 per site
- Each site ~2.5 km^2
- Distance covered inland ~2 km
- Mostly private, domestic, shallow open wells, a few deep tube wells
- 5 field trips between March and July
- 39 % of wells were flooded

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Multi-Parameter TROLL 9000

Rugged Design

Smallest Size, Most Features

The TROLL 9000 is the ultimate tool for <u>profiling</u>, <u>surveying</u> and <u>long-term monitoring</u>.

- 45mm (1.75") outer diameter
- Marine-grade (industrial) 316-Stainless Steel design
- Integrated Quick-Connect cable - no need for additional supports
- <u>EVERYTHING NEED IS IN ONE UNIT</u>
  - ⇒ Sensors
  - ⇒ Data Logger
  - ⇒ Clock
  - ⇒ Power

Multi-Parameter TROLL 9000

The Most Sensors

The Most Sensors in a 45mm (1.75") diameter body

- Up to 9 sensors simultaneously!
- Each sensor has been specially designed to provide extra long-life and low-drift.

Multi-Parameter TROLL 9000

Handhelds

Pocket-Situ software for the COMPAQ iPAQ COLOR Pocket PC!

Powerful instrument controller

- All of the features of Win-Situ
- View data in Graph OR Meter format
- View data real-time!
- Download data, calibrate sensors, setup logging

It's also a fully functional PDA

- Store contacts, make schedules
- Use Pocket Word, Excel, play games, etc.

Pocket-Situ Kit

Pocket PC Docking Station

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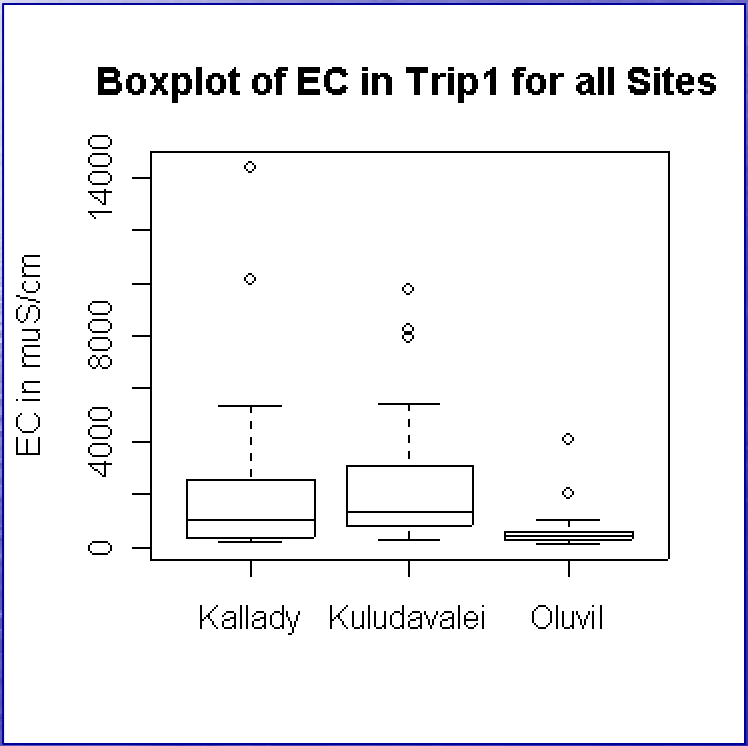
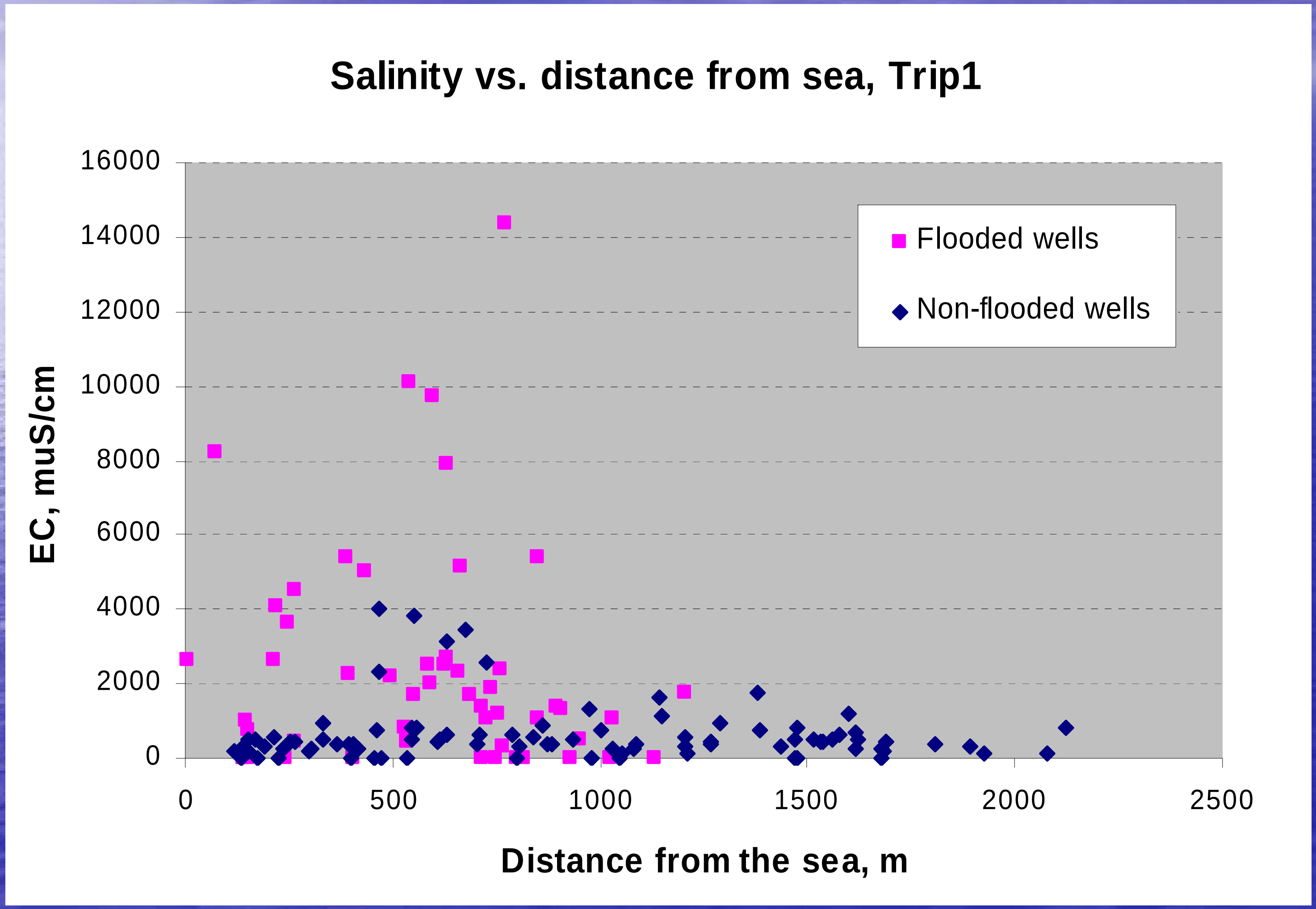
Areas were impacted differently

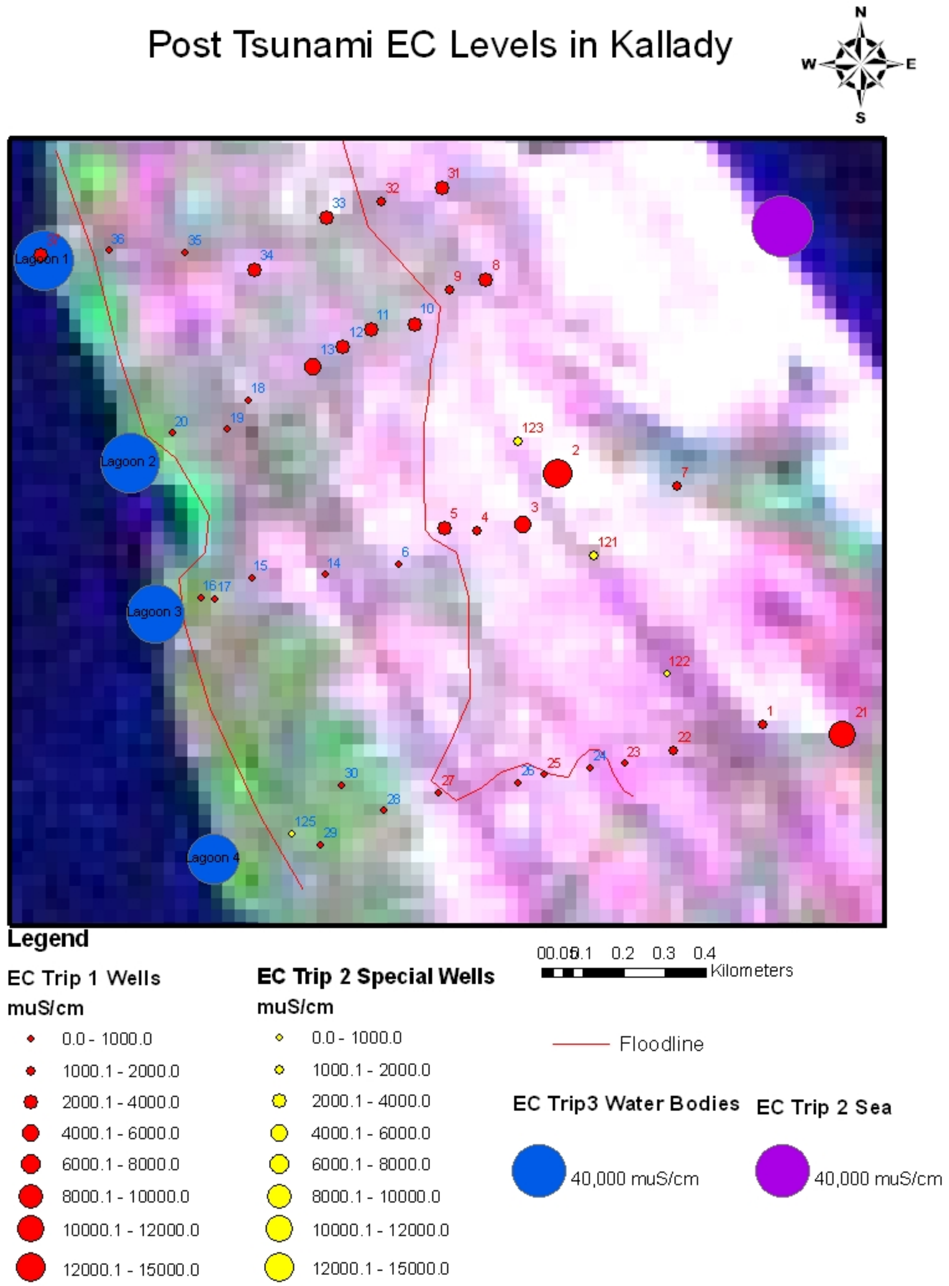


	Kallady	Kalutha-valai	Oluvil	Total
No. of wells monitored	43	49	56	148
No. of wells flooded	21 (49%)	24 (49%)	12 (21%)	57 (39%)
Max. distance of flooded wells	1.3 km	1.2 km	0.6 km	

Distance of impact



Post Tsunami EC Levels in Kallady



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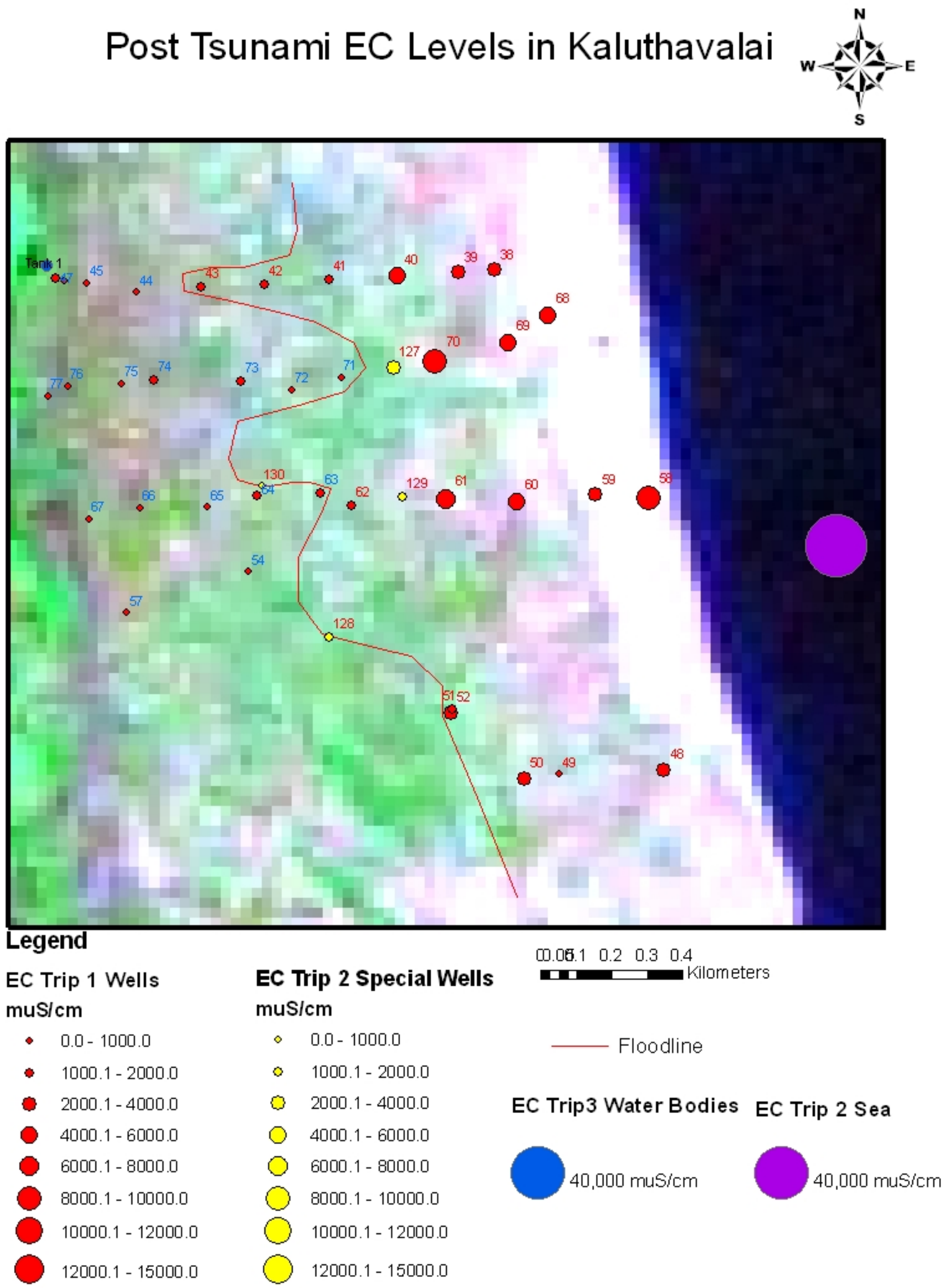
Post Tsunami EC Levels in Kaluthavalai



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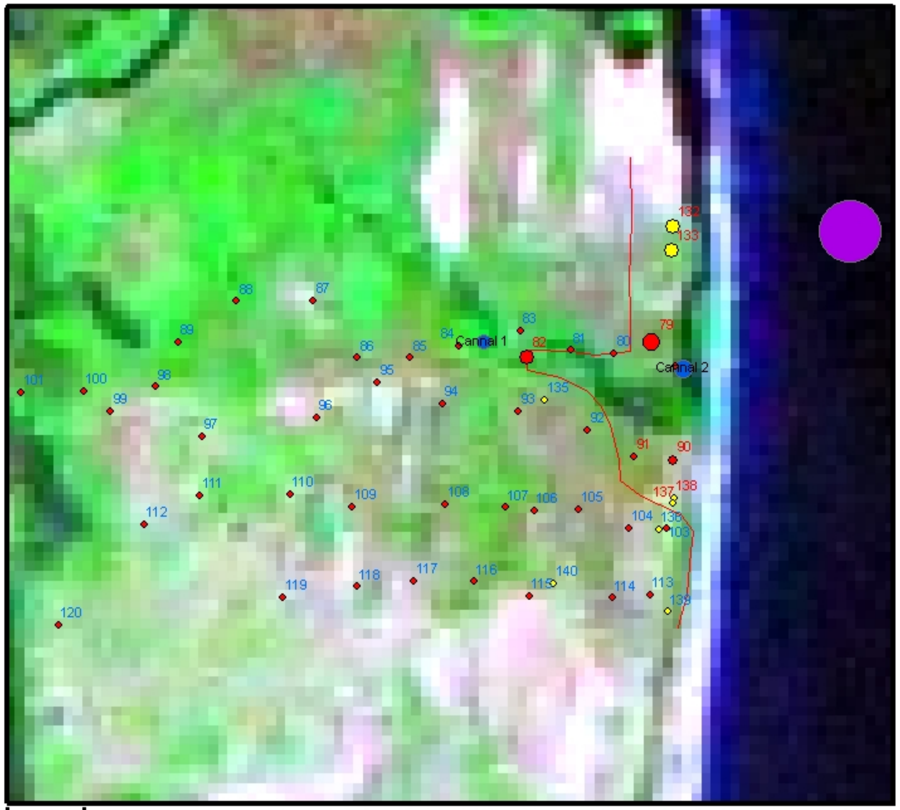
Post Tsunami EC Levels in Oluvil



Legend

0 0.05 0.1 0.2 0.3 0.4 Kilometers

EC Trip 1 Wells muS/cm

- 0.0 - 1000.0
- 1000.1 - 2000.0
- 2000.1 - 4000.0
- 4000.1 - 6000.0
- 6000.1 - 8000.0
- 8000.1 - 10000.0
- 10000.1 - 12000.0
- 12000.1 - 15000.0

EC Trip 2 Special Wells muS/cm

- 0.0 - 1000.0
- 1000.1 - 2000.0
- 2000.1 - 4000.0
- 4000.1 - 6000.0
- 6000.1 - 8000.0
- 8000.1 - 10000.0
- 10000.1 - 12000.0
- 12000.1 - 15000.0

Floodline

EC Trip3 Water Bodies

40,000 muS/cm

EC Trip 2 Sea

40,000 muS/cm

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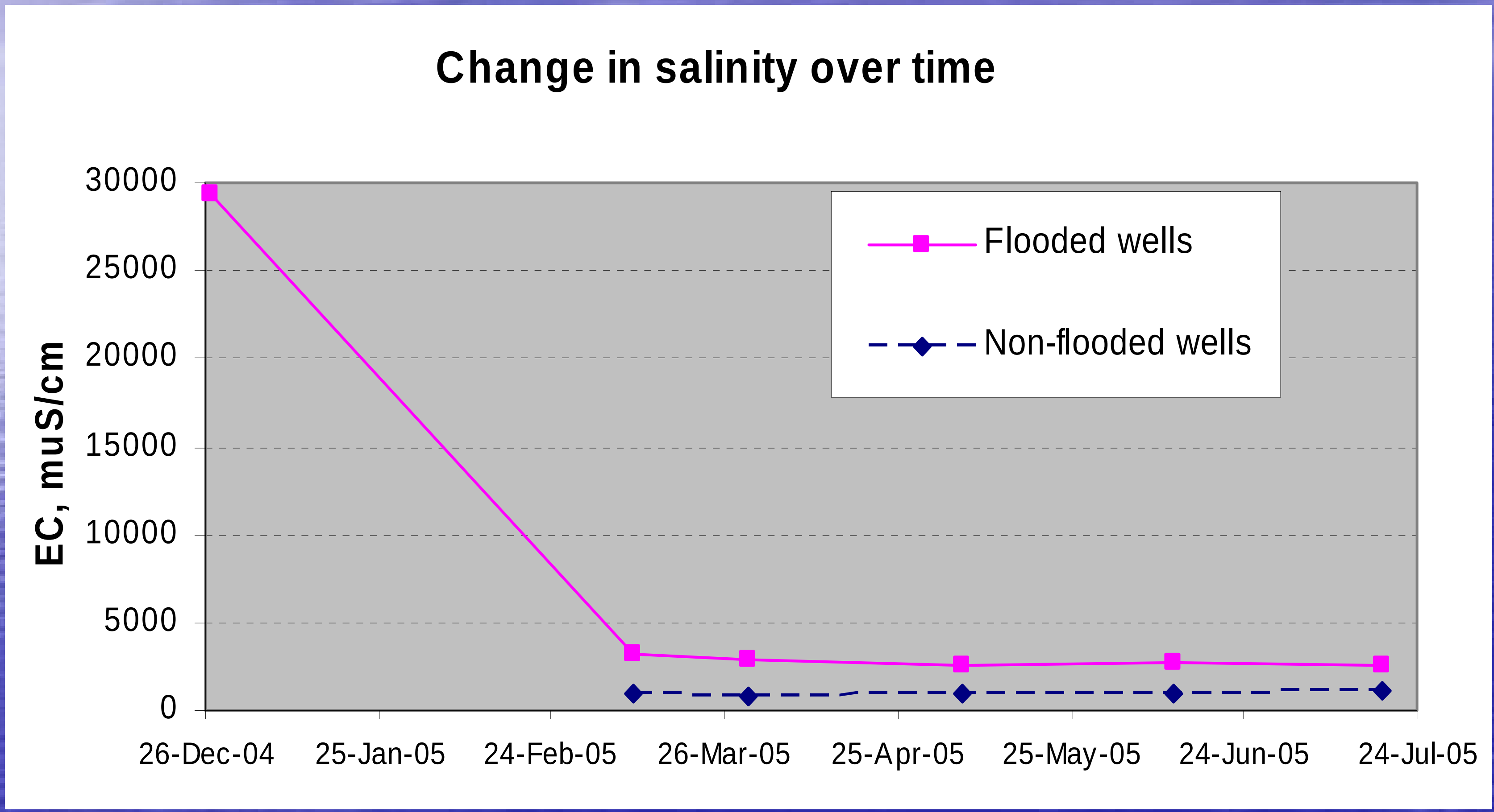
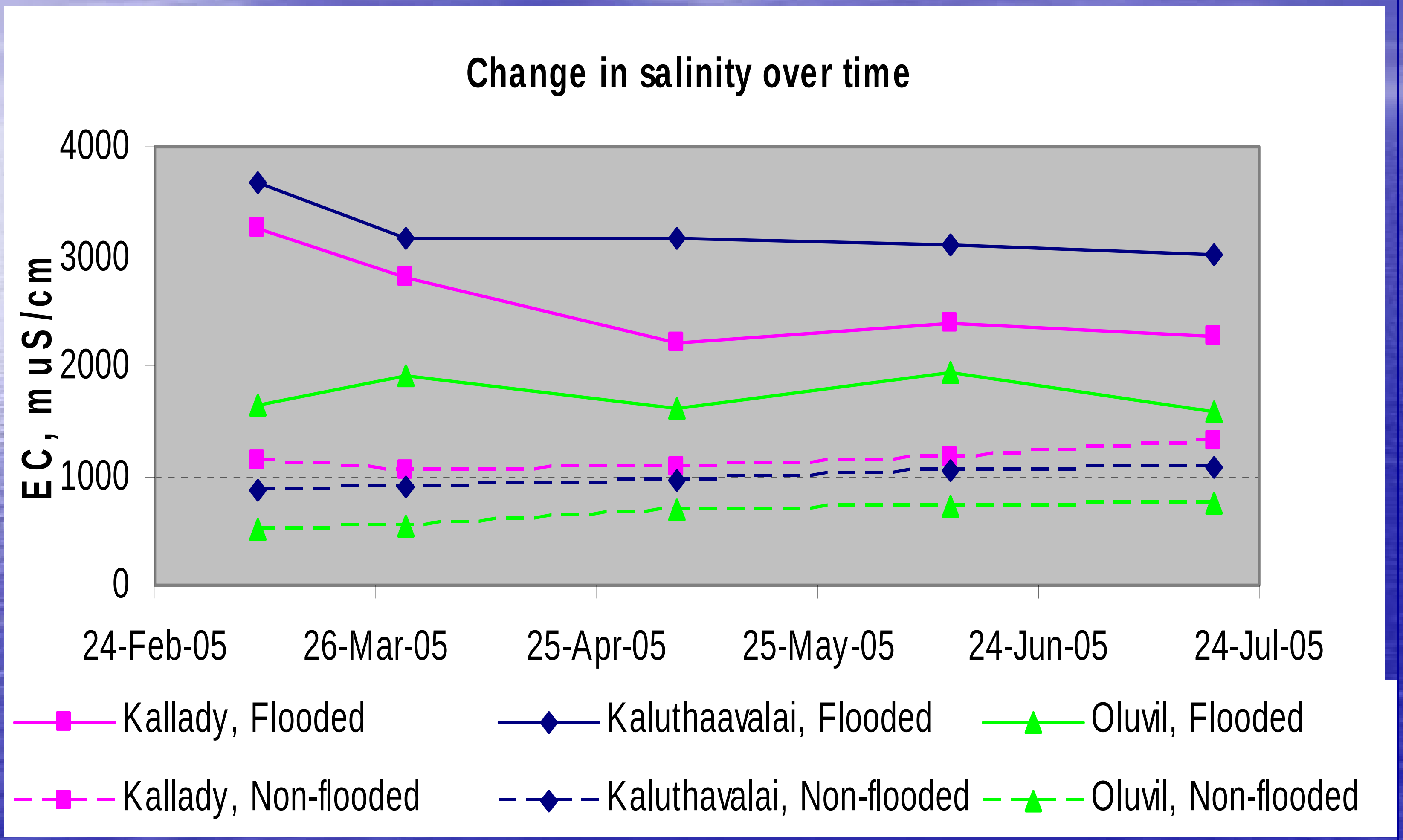
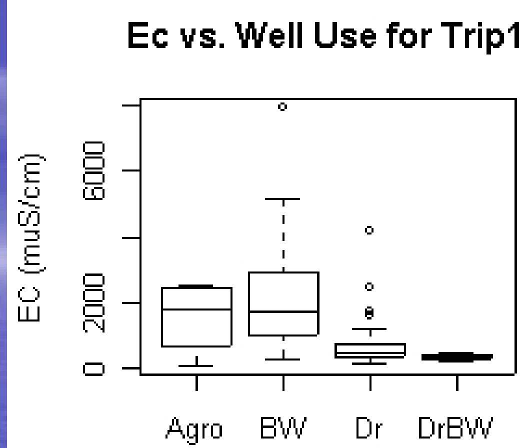
Change in salinity with time

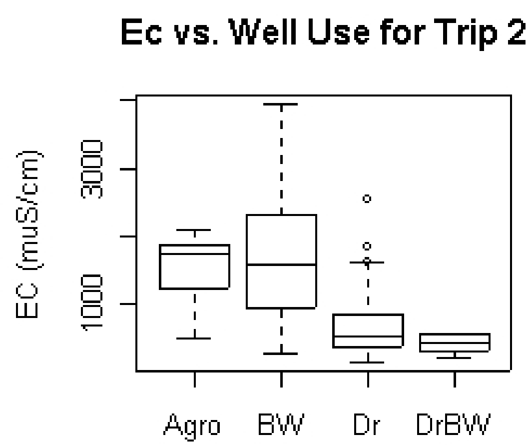


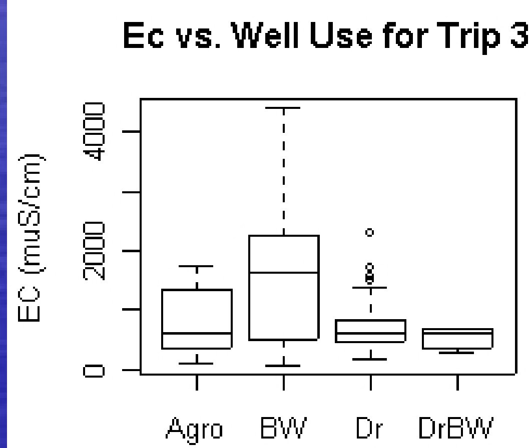
Change in salinity with time, cont.



Salinity governs use of water







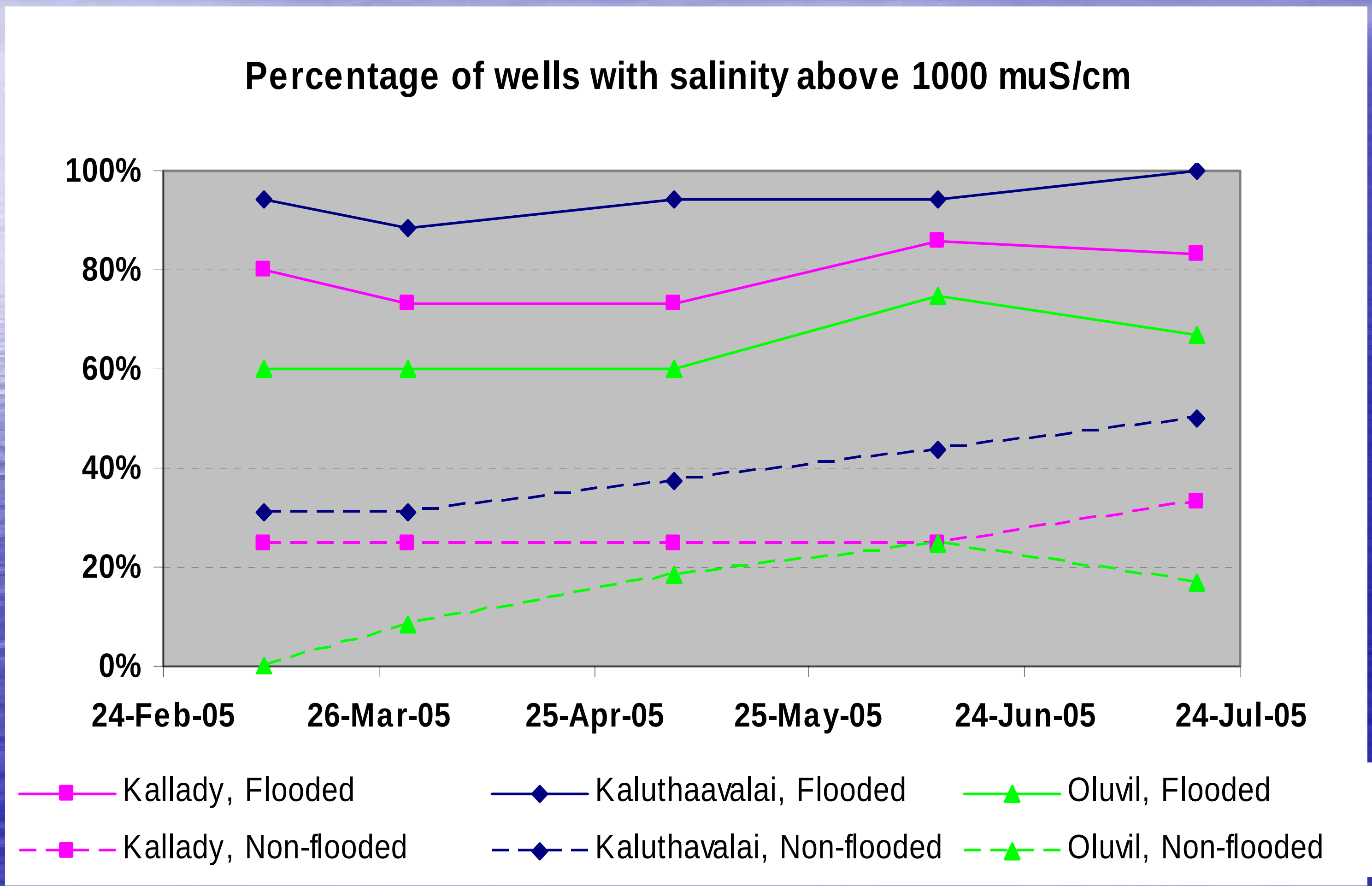
Uses:

Agro: Irrigation

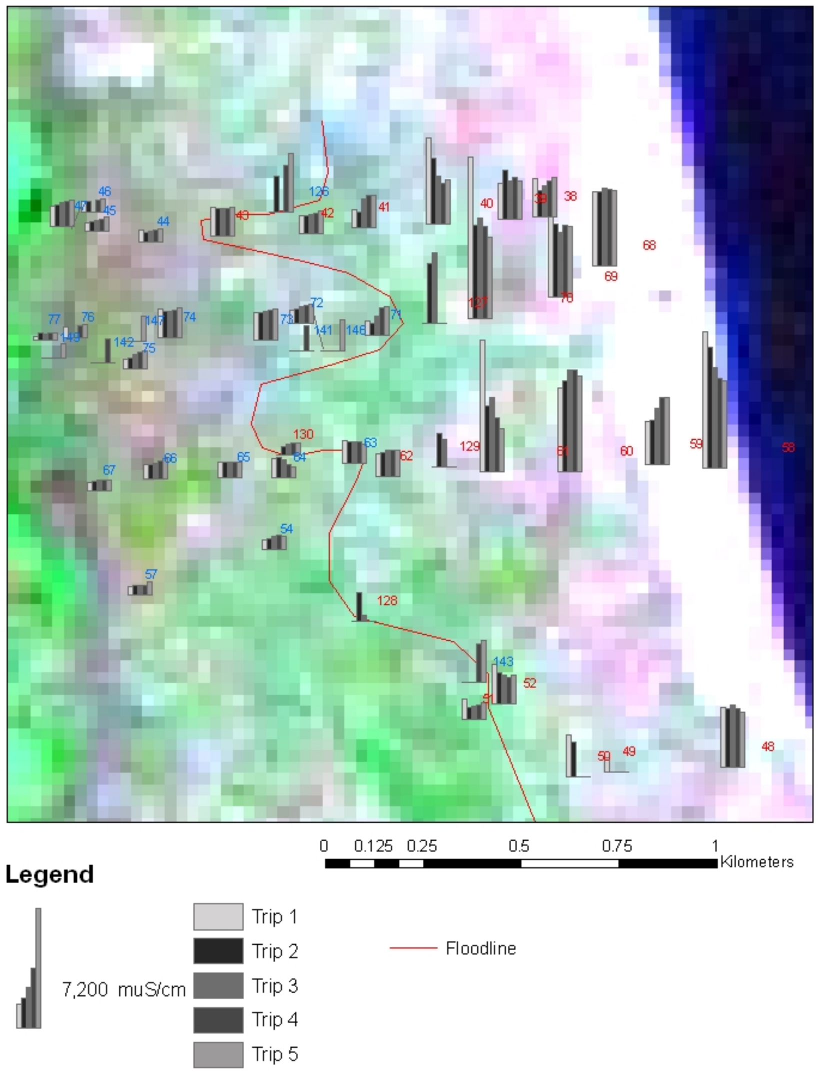
BW: Bathing/Washing

Dr: Drinking

Proportion of wells unsuitable for drinking



Change in Salinity Levels in Kaluthavalai



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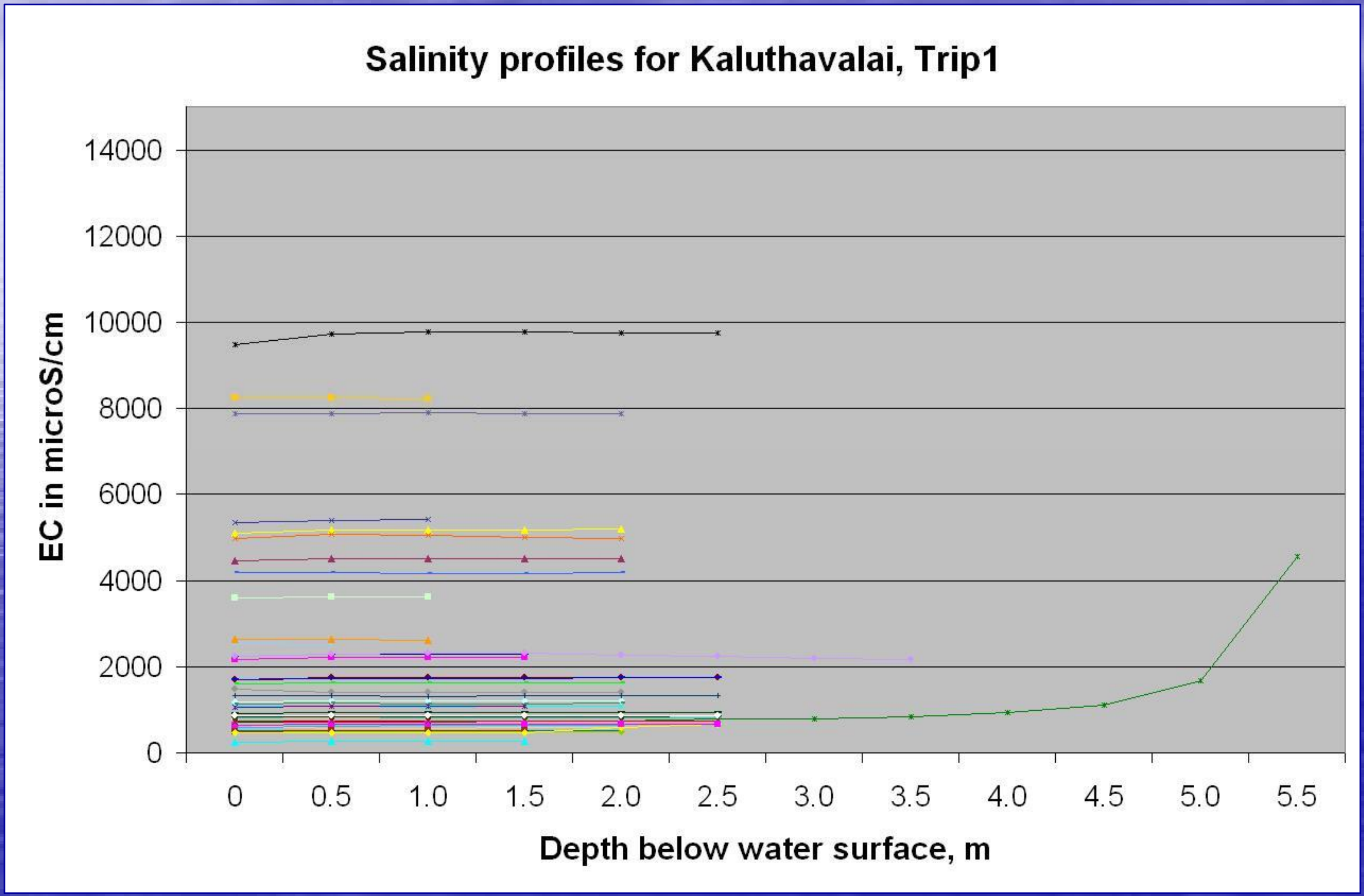
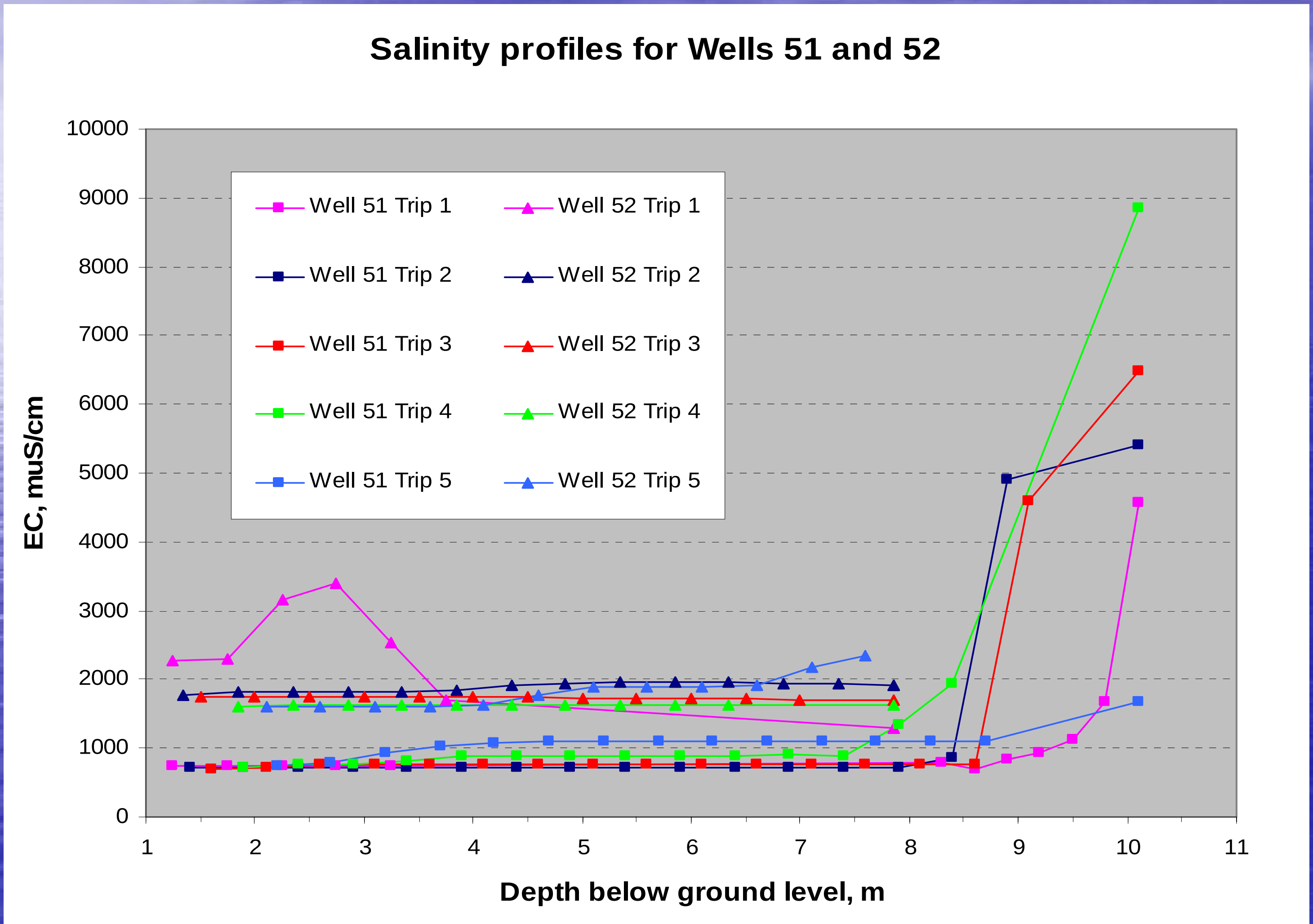
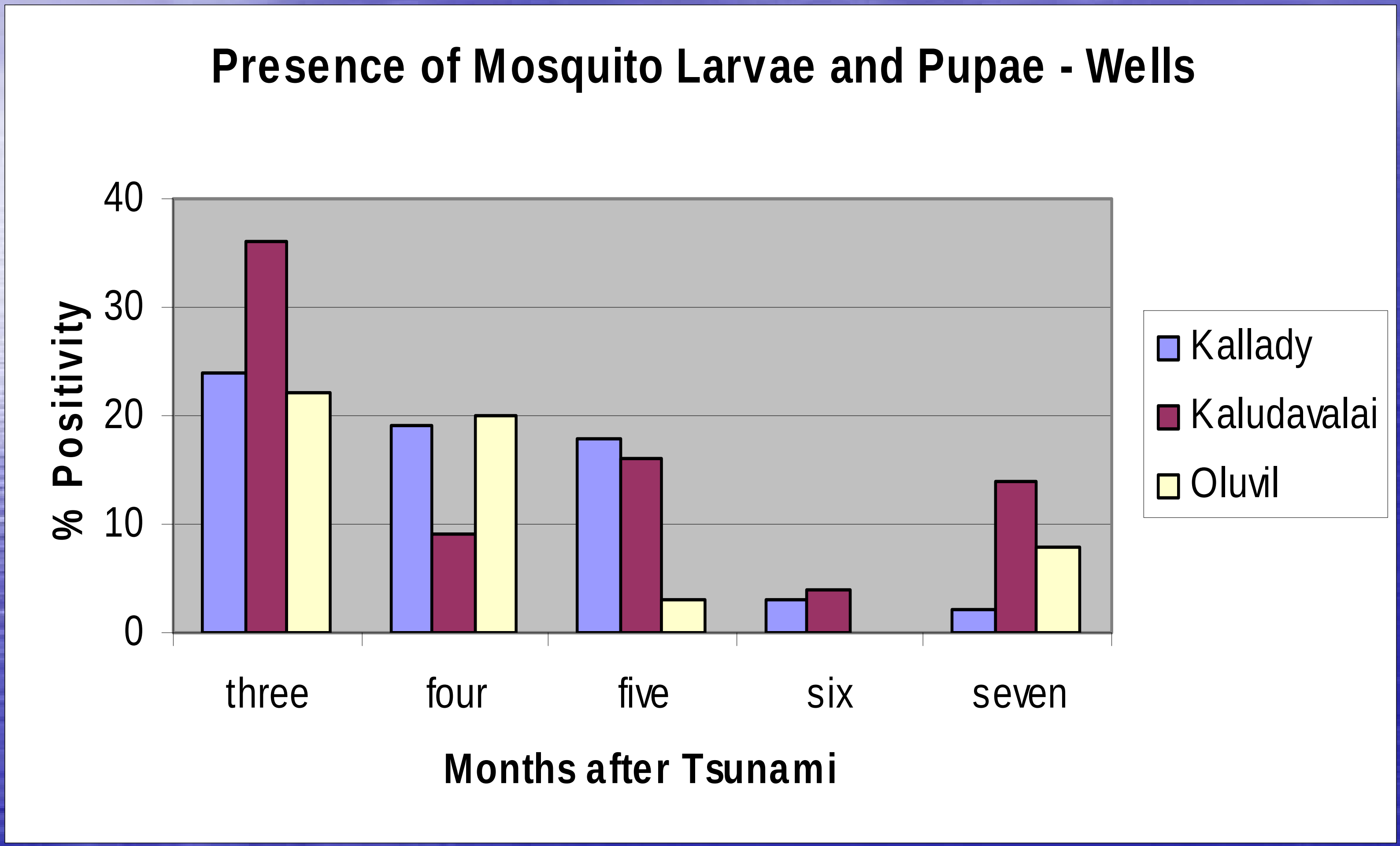
Salinity with depth



Salinity with depth, cont.



Presence of mosquito larvae



Source: Priyanie Amerasinghe, IWMI

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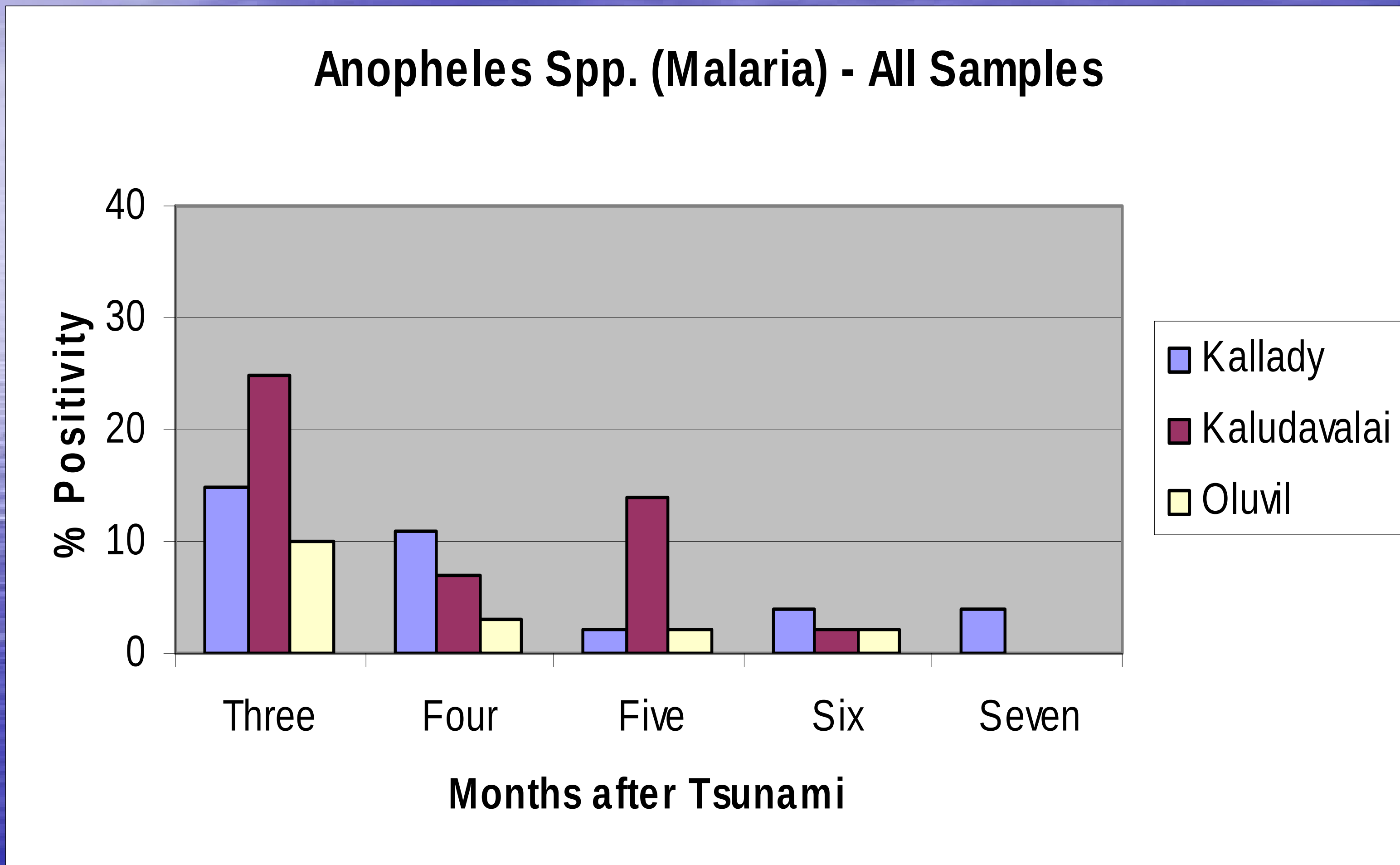
Presence of potential malaria vectors



Source: Priyanie Amerasinghe, IWMI

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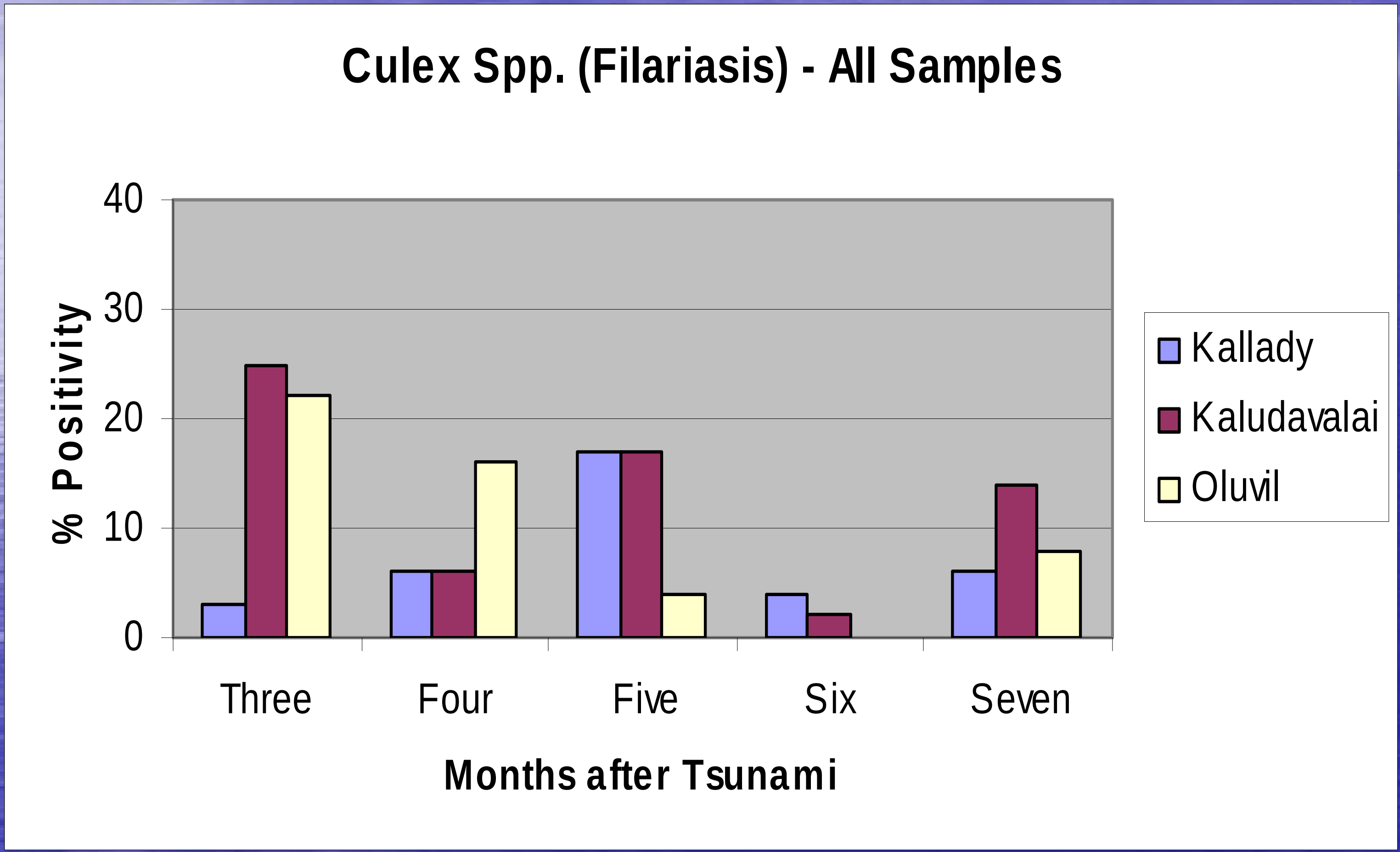
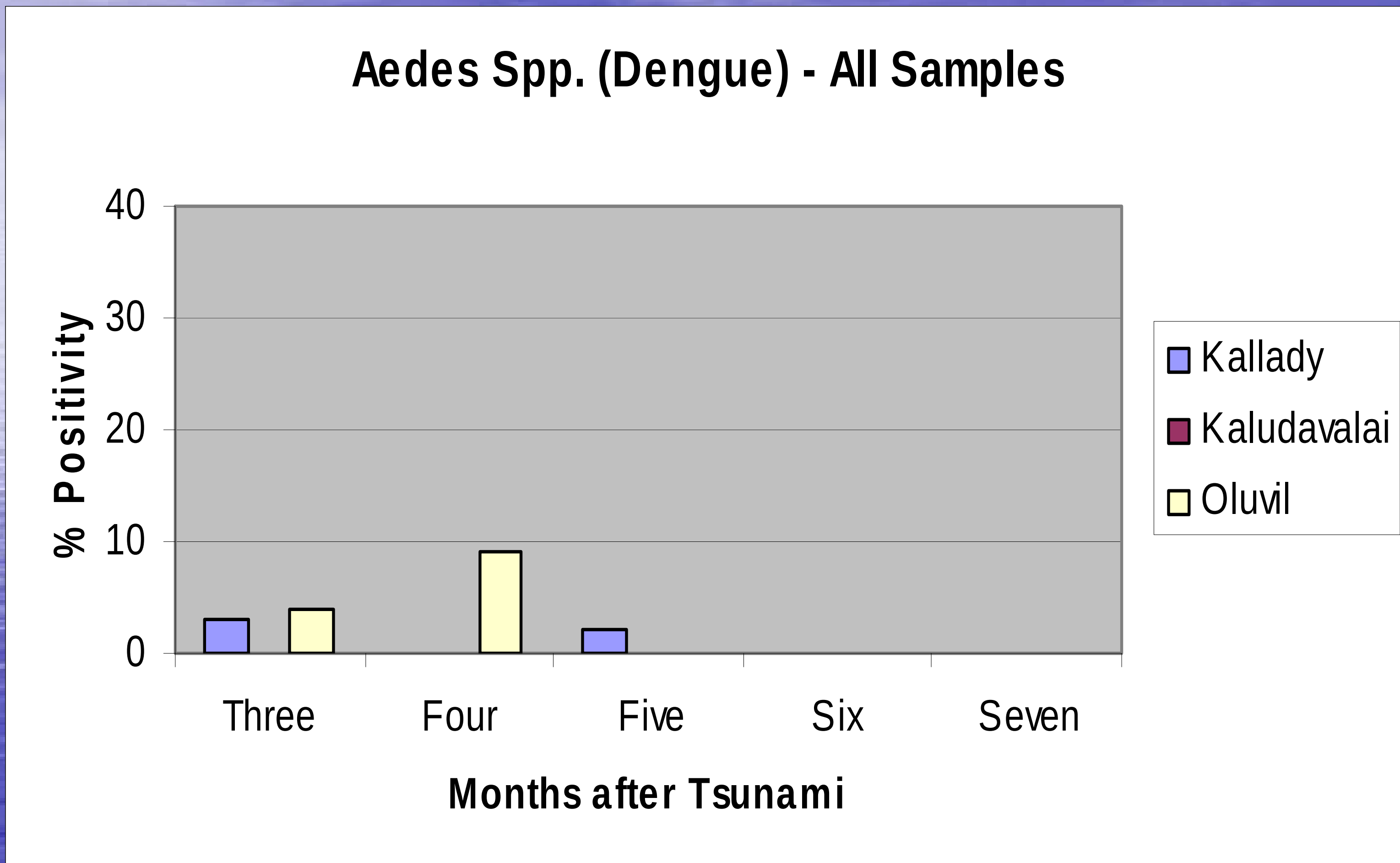
Presence of potential filariasis vectors



Source: Priyanie Amerasinghe, IWMI

Presence of potential dengue vectors



Source: Priyanie Amerasinghe, IWMI

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Findings

- Wells affected up to 1.3 km inland
- Well salinity varied significantly in flooded areas due to various flooding patterns, soil and well characteristics and possibly post-tsunami pumping and cleaning impacts
- Salinity initially decreased rapidly, but residual salinity may persisit for longer times
- Rainfall is the primary remedial agent

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Findings, cont.

- The majority of wells in flooded areas are still unfit for drinking
- Persistent high salinity levels at bottom of 10 m deep well may indicate bottom of freshwater lens
- Recovery of wells requires at least one more rainy season

Recommendations for pumping and rehabilitation

- Don’t concentrate pumping for bowsering in same wells for extended times
- Distribute pumping to more, interchangable wells
- Wells that are pumped intensively (agro and bowser) should be monitored for salinity
- If salinity increases, pumping should be discontinued
- Preferably, pump from shallow wells away from the coast, and away from other sources of pollution
- Implement means to catch and infiltrate rainwater

Future needs and requirements

- Continuous monitoring, expand to look at other potential threats to groundwater, e.g. nitrate and pesticides
- Users, NGOs and local authorities need to monitor wells in heavy use, and follow recommendations
- The coastal areas can be supplied by groundwater in the future provided:
  - Protection
  - Awareness

Thank you!

Why focus on the coastal aquifers?

- The water supply in the coastal areas is heavily dependent on freshwater from these aquifers
- The majority of the flooded areas were underlain by these aquifers
- They are naturally vulnerable to contamination and over-pumping

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The coastal aquifers are good water sources

- Generally replenished with good and sufficient rainwater
- No natural groundwater contamination, like fluoride or arsenic
- High-yielding, shallow wells
- Only potential threat from saltwater intrusion

→ Water on-demand, on-the-spot

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However, the aquifers are also very vulnerable

- They are very permeable, allowing rapid infiltration of pollutants
- They are shallow and unconfined and with little retention capacity (i.e. in the form of organic matter), which also facilitates fast leaching of pollutants into the subsurface
- They are bounded by saline groundwater, and saltwater intrusion due to over-pumping is a real risk posing restrictions on amounts and means of pumping

Real and potential risks to the aquifers

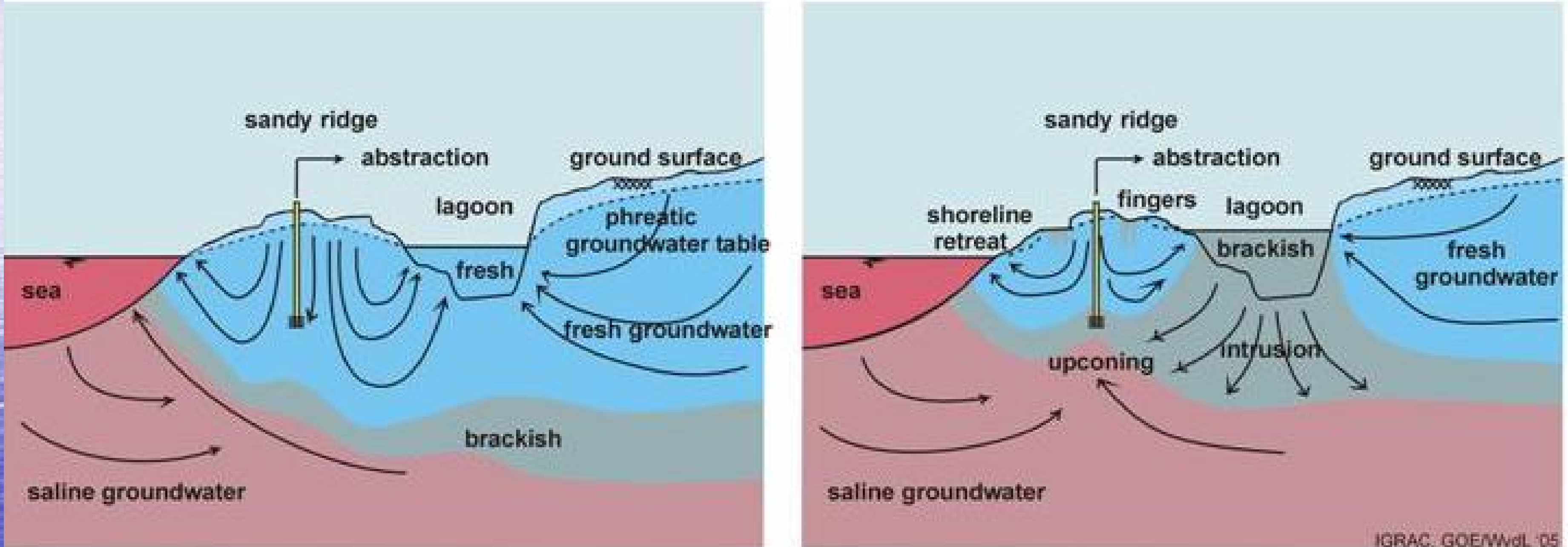
- Tsunami. Salinity may persist as a problem for one or two seasons
- Population growth, resettlement => more concentrated pumping in some areas
- Increased pressure from agriculture and industries
- Alternative groundwater resources from aquifers more inland are not as abundant, reliable and adequate in natural water quality as the coastal aquifers

Effect of the tsunami on the coastal aquifers

- Saltwater effects
- Destruction of wells
- Coastline retreat
- Obstructed drainage
- Contamination from spills, waste

Saltwater effects of the tsunami

Cont.....



Before the Tsunami

After the Tsunami

Risk of upconing of saltwater is higher when

- Pumping is intensive, causing removal of a large part of the standing water in the well
- Pumping from wells close to the coast
- Wells are deep
- Pumping is performed in the dry season when the saltwater lens is smaller

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Other side-effects of intensive pumping

- Well collapse
- Cross-contamination from pit latrines
- Increased turbidity

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Recommendations

1. Do not pump to try to remove saltwater, especially not now when salt and freshwater have mixed and saltwater is moving away from wells
2. If salinity increases rather than decreases, stop pumping all together
3. Pumping for cleaning (other than salt) should be done cautiously and with accompanying salinity measurements
4. Do not drill deeper to get freshwater