Experiences responding to outbreaks of infection with *A. invadans* (epizootic ulcerative syndrome) in Africa

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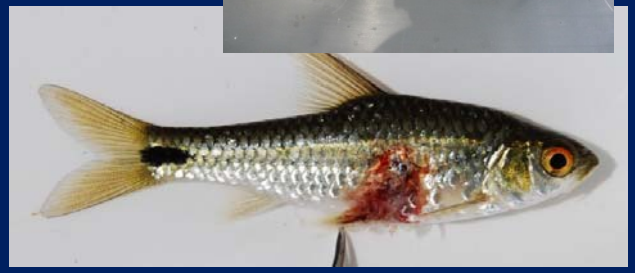
Aphanomyces invadans

- Obligate pathogen of fish
- An invasive aquatic oomycete or water mould
- Oomycetida - classified with diatoms and brown algae in a group called the Stramenopiles or Chromista
- Distinct from other saprophytic water molds
- *Never reported from Africa prior to 2017*

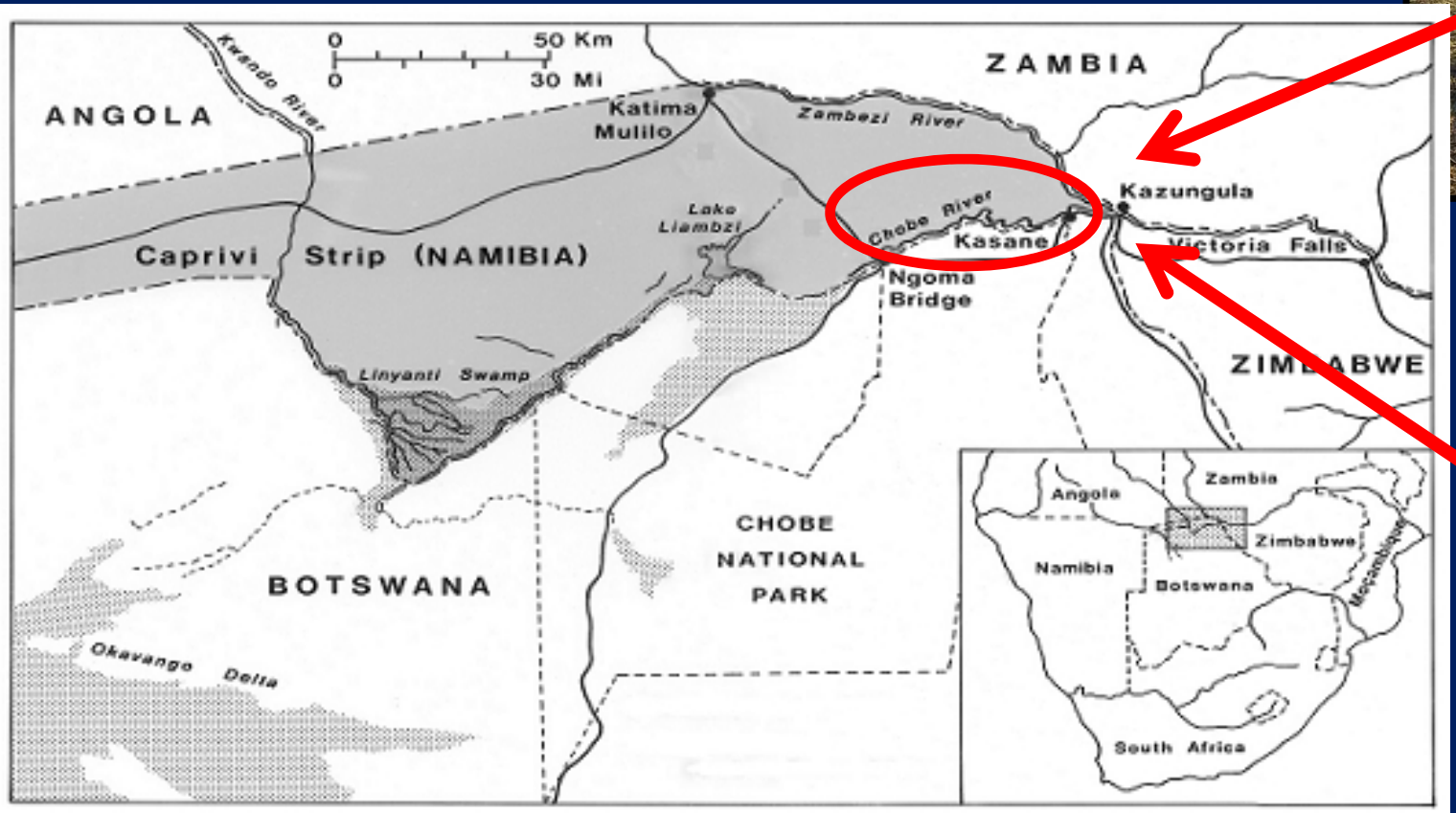


Many of the Straminopiles are pathogens of plants and animals. A number of these have had devastating effects on agriculture and aquaculture throughout the world

2006 - first EUS outbreak on the African continent

Rhodes University, South Africa at request of Botswana Department of Wildlife and National Parks

Field laboratory on the Chobe River, Botswana, April 2007



FAO/AAHRI/NACA/Bostwana DWNP Emergency Disease Investigation
Task Force on a Serious Fish Disease Outbreak in the Chobe-Zambezi River System (Botswana Mission 18-26 May 2007)

- During 2007 and 2008 data on EUS were first collected in the Caprivi Province of Namibia during regular biological surveys by B.C.W. van der Waal using experimental gill nets, *ad hoc* scoop net sampling, inspection of fishermen's catches, annual angling competitions and casual angling.

Scoop nets used in shallow vegetated areas – an effective means of targeting moribund fish

The Zambezi floodplains, at the confluence with the Chobe River, span across four countries: Botswana, Namibia, Zambia and Zimbabwe, making disease control a challenge.

FAO launches Regional Technical Cooperation Programme (TCP/RAF/311[E])

- "Emergency Assistance to Combat EUS in the Chobe-Zambezi River" was approved for implementation covering seven participating southern African countries (Angola, Botswana, Malawi, Mozambique, Namibia, Zambia and Zimbabwe)

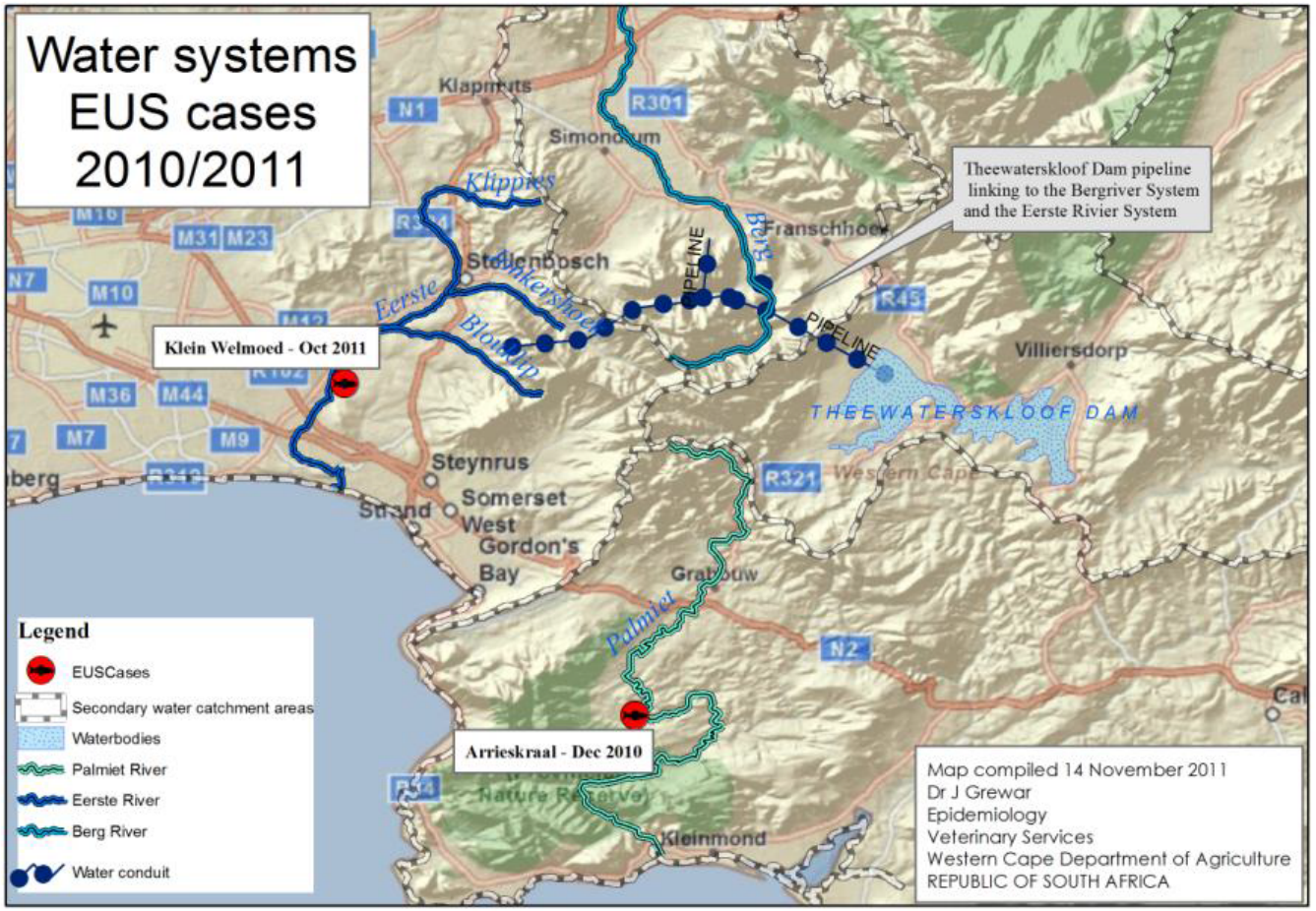
Regional spread of EUS continues from the site of the first outbreak

- 2007 onwards outbreaks along the upper Zambezi and Kafue rivers in Zambia
- Upstream spread of the disease associated with large scale fish mortality
- 2010, outbreaks of EUS in fish first reported from the Okavango Delta in Botswana,
- 2011, outbreak of EUS reported from Lake Liambezi in Namibia.

2010 - first EUS cases in South Africa

- Recognized in an artifical impoundment in the Palmiet River in the Western Cape Province
- Reported to the OIE in February 2011
- Cage farmed trout were unaffected
- Lesions were confirmed in large mouth black bass (*Micropterus salmoides*), in blue gill sunfish (*Lepomis macrochir*) and in an unidentified cichlid species

- Serious mortality amongst free-living sharptooth catfish (*C. gariepinus*) in a farm dam on the Eerste River near Stellenbosch in the Western Cape in October 2011



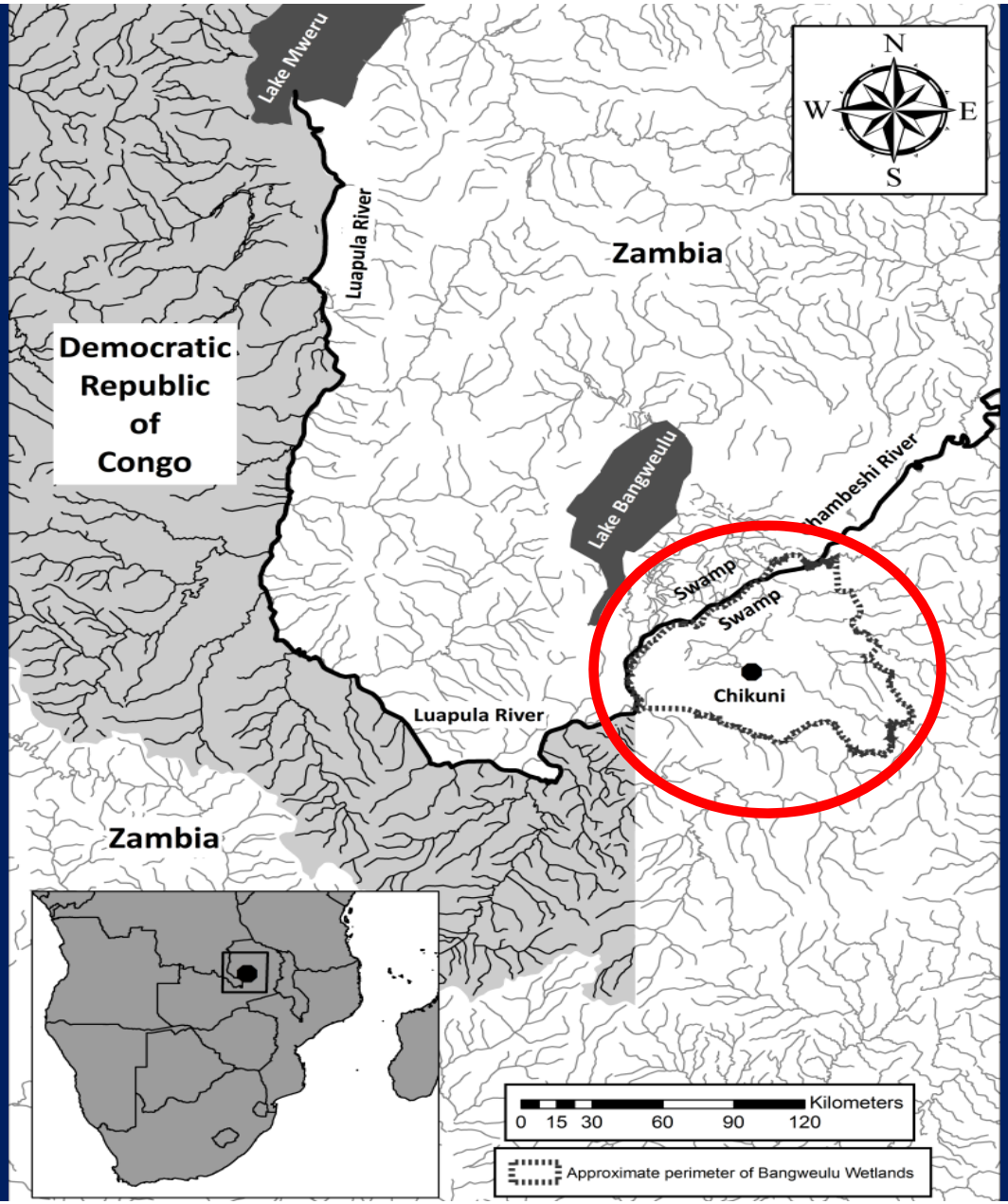
Map: Dr J. Grewar, State Vet Epidemiology DAFF

2014 first outbreak of EUS in the Congo River catchment

- Bangweulu swamps – an inland delta, in the north of Zambia
- First outbreak of EUS during 2014, repeated 2015, 2016, 2017

- Large and diverse fish fauna related to, but distinct from, that of the Zambezi River system
- A sizeable artisanal fishery, based on extensive fish weirs, is sustained by the annual flooding of the swamps

- Bangweulu swamps drain into the Congo River in neighbouring Democratic Republic of Congo, Africa's largest drainage system with an extensive and diverse fish fauna previously unaffected by EUS



Bangweulu swamps – Northern Zambia

In Southern Africa EUS has had its greatest impact on floodplains and flood plain fisheries have been particularly hard hit. The annual flooding cycle in the floodplains of the Zambezi system and elsewhere creates conditions particularly favourable to outbreaks of EUS.

EUS in the Bangweulu floodplain fishery

Lessons from the Bangweulu outbreak - Social consequences

- Fishermen confirmed that they had never before seen a disease like this in the area.
- A range of explanations were developed ranging from:
  - bird injuries, to
  - witchcraft and
  - deliberate infection of the fish as a punitive measure by authorities.
- Fishing communities were concerned about the safety of consuming and trading infected fish
- Rapid emergence and spread of the disease lead others to fear extinction of the fish stocks.
- The emergence of the disease was became a major issue in the fishing communities and began to result in unrest.

Significance of the outbreak for the local community

The Bangweulu floodplain and swamp:

- Supports one of the largest artisanal fisheries in Zambia.
- Fish are harvested seasonally through an extensive and unique network of fish weirs that cover some 7 000 km^2
- Provides the main source of livelihood for an estimated 5 000 fishing families within Bangweulu Wetlands, generating income of approximately $6 million annually

Broad significance of the Bangweulu outbreak

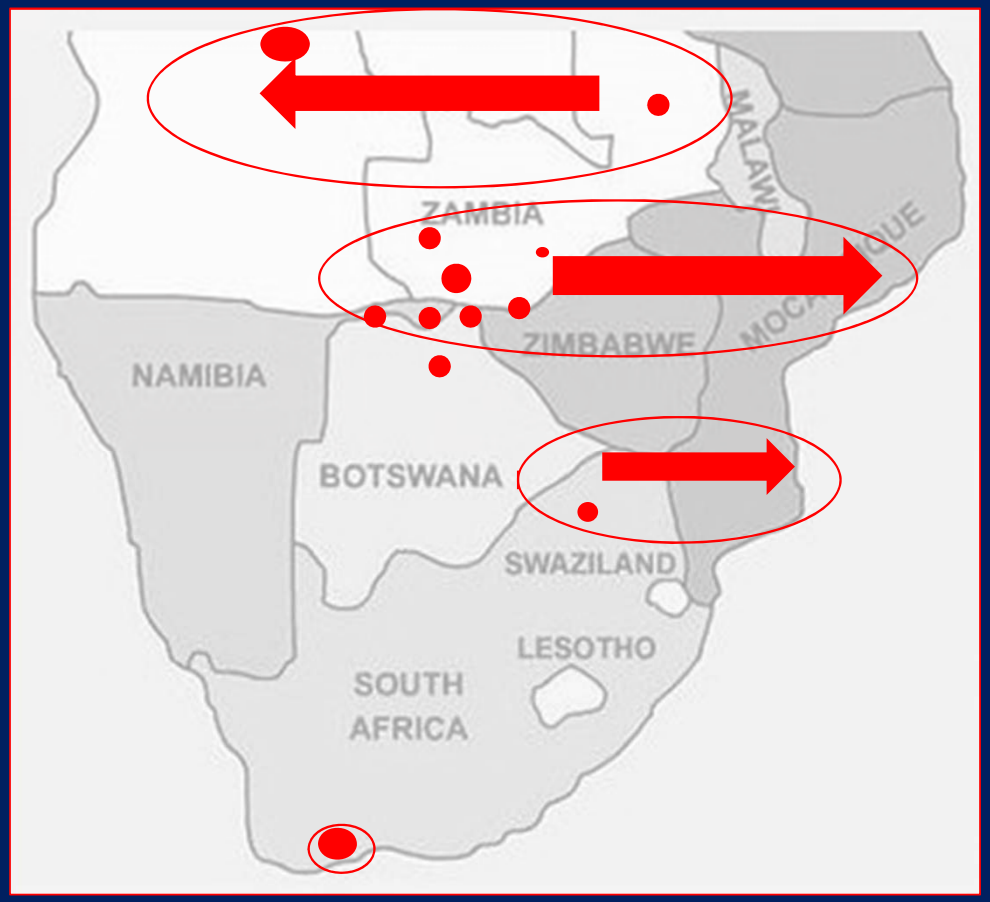
- Chambeshi/Luapula River, regarded as the source of the Congo River, the extensive, oligotrophic Bangweulu swamps with their large, seasonal floodplains, cover a basin of 15 000 km^2 before draining into the DRC.

- Bangweulu swamps form part of the Bangweulu-Mweru Freshwater Ecoregion and contain a significant richness of aquatic biodiversity and a fish fauna that, although related to that of the Zambezi system, shows a greater similarity to the ichthyofauna of the Congo Basin

- The region is considered globally outstanding and of highest conservation priority.

- The Congo Basin has an ichthyofaunal endemism of 75% which now stands to be impacted by EUS

2014 Distribution of known EUS outbreaks in Southern Africa



January 2015 - first outbreak of EUS in the Congo Basin reported from the DRC, affecting the Equateur Province in the north west of that country

FAO International Emergency Fish Disease Investigation Mission on a Suspected Outbreak of Epizootic Ulcerative Syndrome (EUS) in the Democratic Republic of the Congo

FAO emergency task team field laboratory

Businga on the Mongala River in north western DRC during the EUS outbreak early in 2015.

Fish markets provided an important opportunity for disease surveillance. Particularly in this case where three air-breathing species were marketed live. Fish with symptoms of EUS were found amongst all three species; lungfish, catfish and snakehead.

Fishermen at Libala River near Karawa in north western DRC helping to catch fish with a scoop net from a pirogue during the EUS investigation in 2015

Searching the shallows of the Mongala River in north western DRC for fish showing signs of EUS. Note the red-brown colour of the water associated with low pH typical of waters draining from forests.

Loko River near Loko village in north western DRC, another site with many EUS positive fish during the first outbreak of EUS in this country in early 2015. The river, draining tropical rain forest, had a pH of 4.5.

EUS risk factors

- Seasonal flooding cycles that bring about pH changes in water covering inundated vegetation. Under such conditions, cases of EUS have been reported to occur when flood plains drain and when at the onset of the dry season this coincides with a drop in water temperature

- Disturbance of naturally acidic soils by agricultural and urban development, and acid mine seepage into natural water bodies

- Year round presence of low water pH will favour infectivity with *A. invadans* and seasonal flooding cycles that cause migration of fish into swampy areas may promote seasonal outbreaks of disease.

Equatorial rainforests – a special risk case?

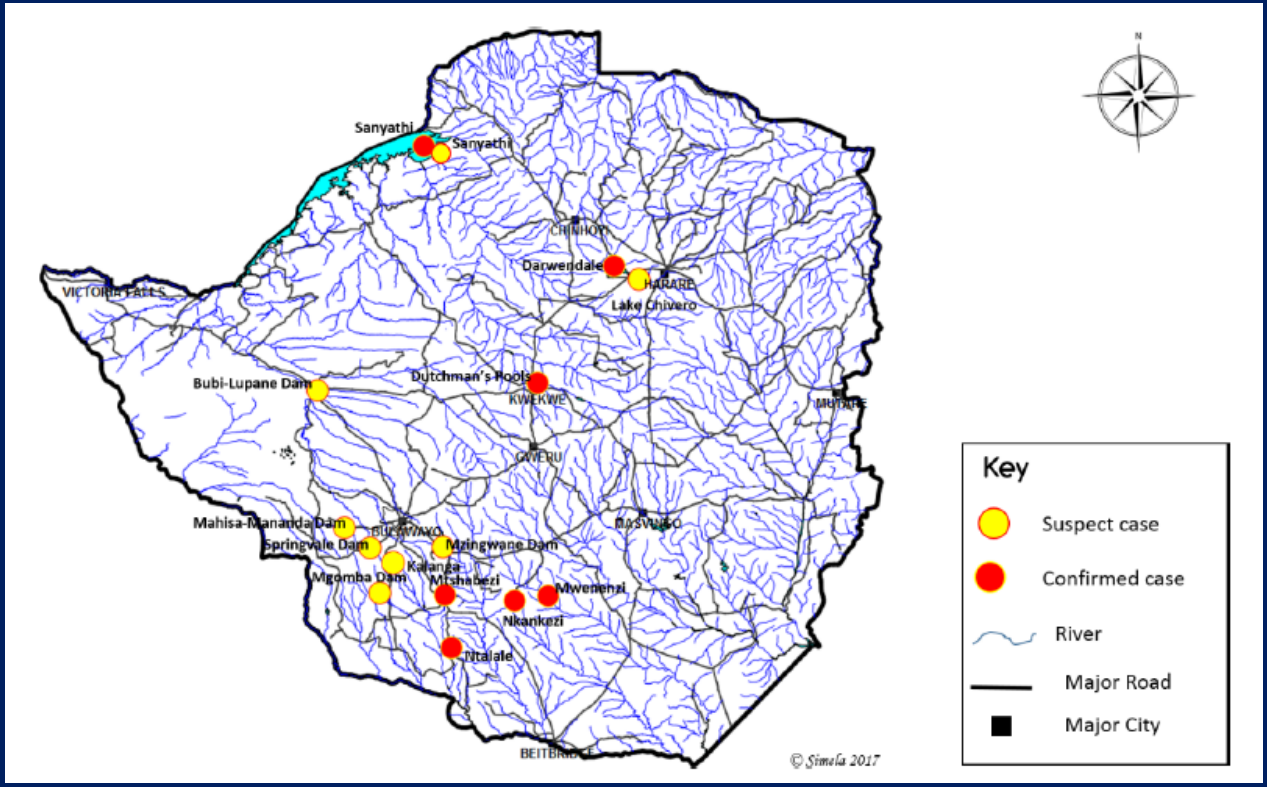
Other ecological and anthropogenic drivers

- Heavy rainfall and flooding that may interlink drainage systems (e.g. Lake Liambezi in 2009, numerous water ways in DRC)

- Traditional live fish market sales of air-breathing fish

- Activities of humans not conforming to appropriate biosecurity measures (recreational anglers, tourism, aquaculture with invasive exotic species)
- Migrant fishers moving with fishing gear to maximize profits from a depleted resource
- Distribution of EUS resistant species in particular Nile tilapia from hatcheries utilizing EUS-infected water sources

Surveillance data from Zimbabwe, published in 2017, indicates wide spread incursion of EUS into multiple catchments of that country



Sibanda S, Pfukenyi DM, Barson M, Hang'ombe B, Matope G. Emergence of infection with Aphanomyces invadans in fish in some main aquatic ecosystems in Zimbabwe: A threat to national fisheries production. Transbound Emerg Dis. 2018;00:1–9. https://doi.org/10.1111/tbed.12922

EUS A threat to national fisheries production

Fish - an important source of minerals in the diet of fishing communities

Traditional commercial flood plain fishery

- Reporting and open sharing of information on EUS needs to be followed up with a coordinated and collective action among and between fishermen, farmers, government agencies and researchers.
- Biosecurity action needs to be applied from the farm to the ecosystem, and at national and international level (Scarfe *et al*.2009)