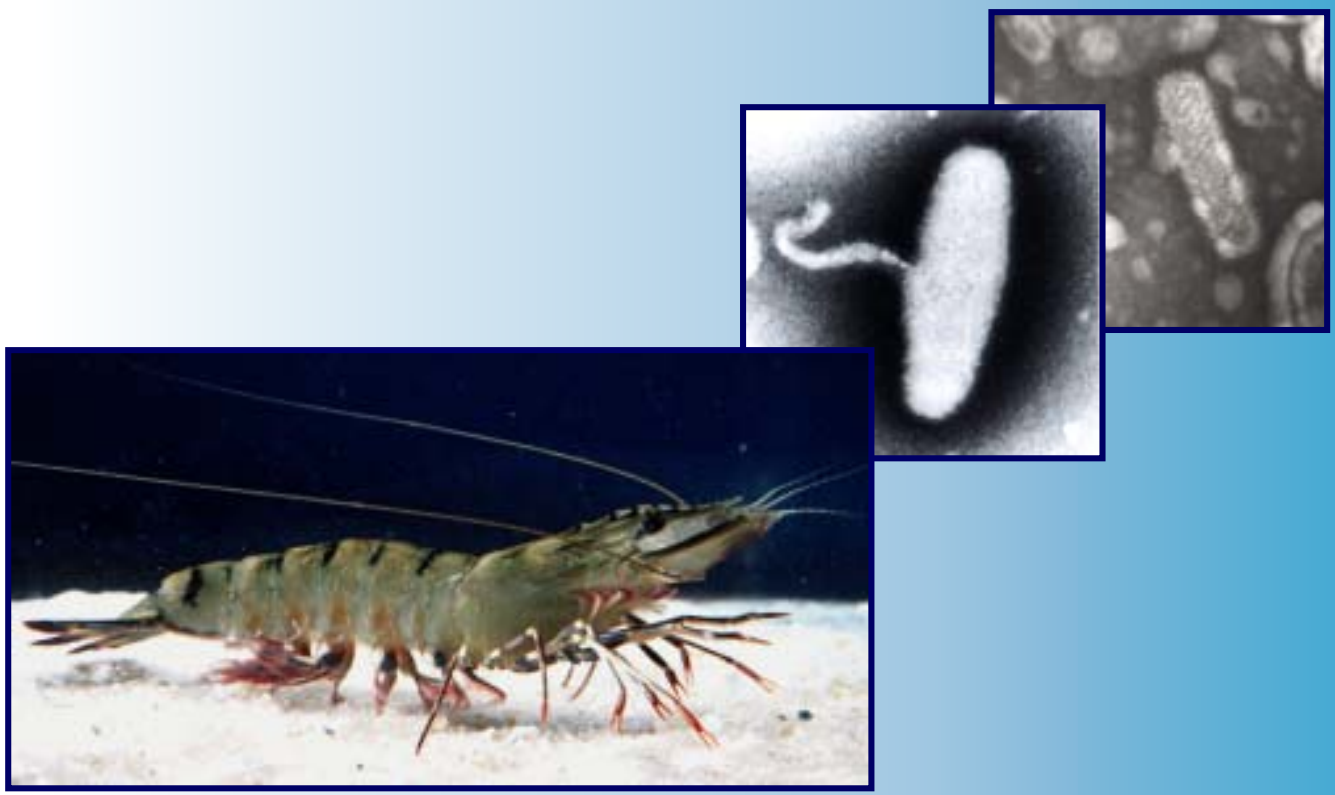
Impact of Infectious Agents on Farming and Food Production

Global Impact of Newly Emergent Pathogens on Farmed Shrimp Production



“There can be no peace until people have enough to eat.
Hungry people are not peaceful people.”

Former US President Jimmy Carter

June 17, 1999

Hunger and food security

- 800 million people are chronically undernourished – mostly in Asia and Sub-Saharan Africa
- 13 million children each year die of hunger or malnutrition
- In Asia alone, 500 million people live on less than $1 /day
- Globally, food security is threatened by drought, population growth, conflict and disease

Food production and infectious disease

Trans-boundary and emerging diseases of field crops, farm animals and fish:

- Threaten food security through serious loss of protein and/or draft animal power for harvest
- Reduce farm incomes and increase poverty in communities dependent on agriculture or fisheries
- Impact on national economies through the disruption and inhibition of trade
- Impact on human health (zoonoses) and on wildlife populations

Issue of growing importance

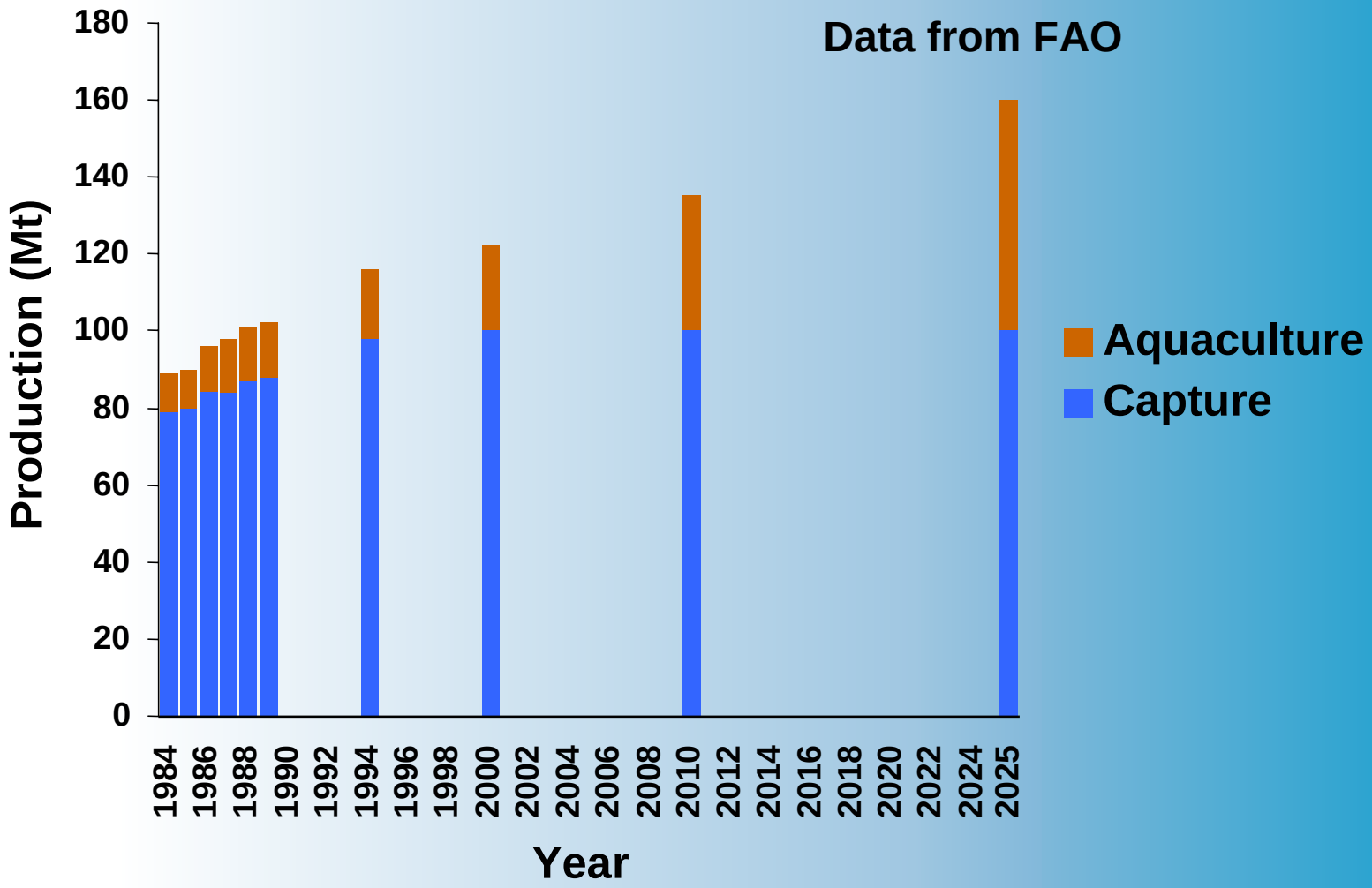
Factors contributing to the volatile nature of trans-boundary and emerging diseases:

- Increasing globalisation and international transport
- Changes in farming production systems
- Farming new ecosystems
- Poor infrastructure for effective diagnosis, local disease management and regulation of animal and crop movements
- Common occurrence of pathogen carriers with no obvious signs of disease
- Global warming

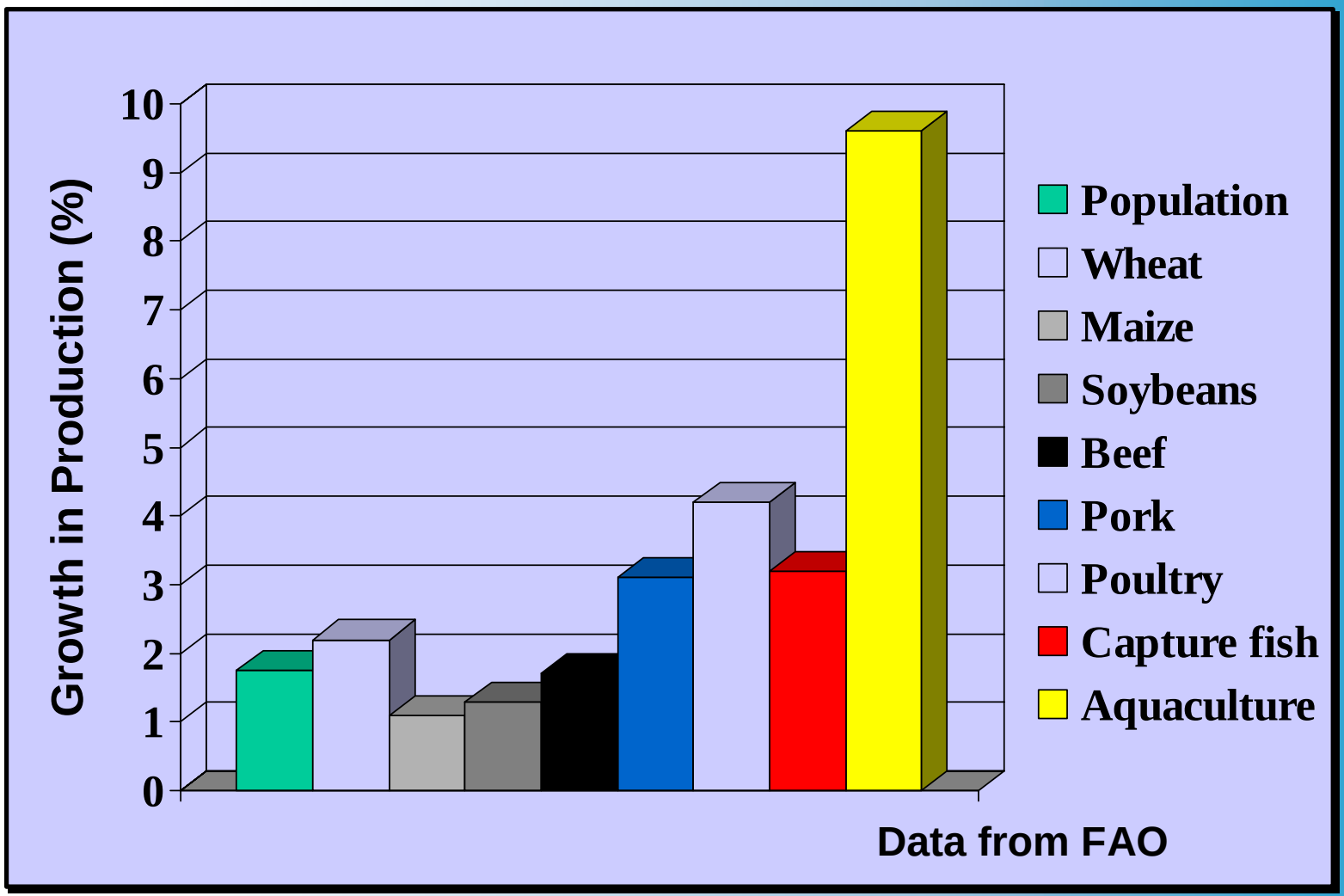
Some emerging diseases of food animals and field crops

Disease	Host	Emergence	Agent
BSE	Cattle	UK 1986 – profound impact on European cattle industry	Prion
Foot and mouth disease	Cattle, pigs, sheep	Re-emerging in 1990s - major impact in Asia & Europe	Picornavirus
Nipah encephalitis	Pigs	Malaysia 1999 45% pigs slaughtered	Paramyxovirus
Geminivirus diseases	Many crops species	Whitefly-vectored viruses - emerged explosively in 1990s	Geminiviruses
Rice stripe necrosis	Rice	Ivory Coast 1975 – since 1991 also in Central America	Furovirus
Potato late blight	Potatoes	Ireland 1840s, re-emergence since 1970s	*Phytophthora infestans*

Looming gap between supply and demand for seafood



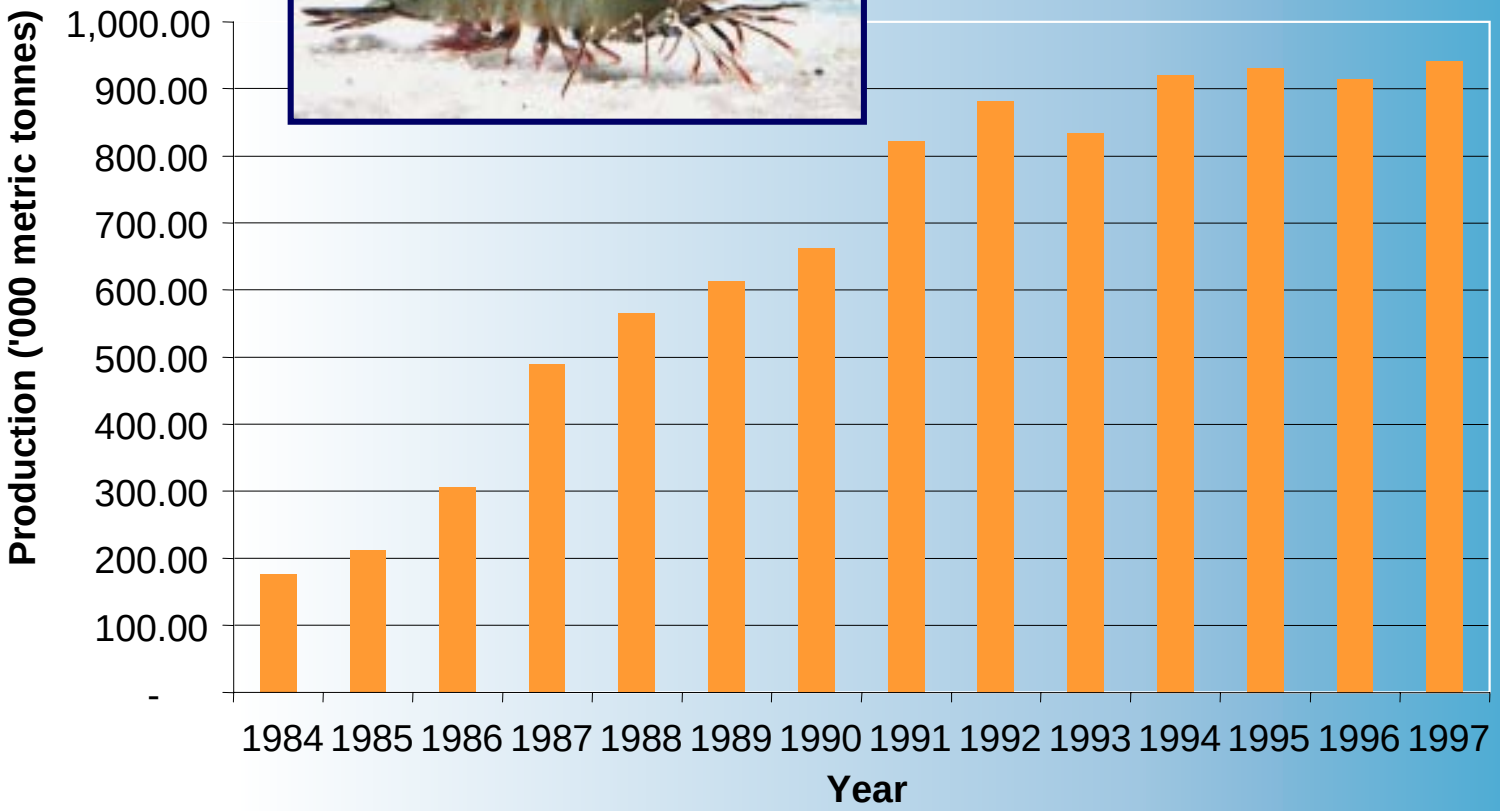
Growth in world food production



Emerging diseases of aquaculture

Disease	Host	Emergence	Agent
Epizootic ulcerative syndrome	Many fish species	Japan 1971 – now throughout Asia and present in USA	Aphanomyces
Viral nervous necrosis	Many fish species	Japan 1990 – now a global problem	Nodavirus
Epizootic haematopoietic necrosis	Fish, reptiles, amphibians	Australia 1984 – now global problem	Iridovirus
White spot disease	Crustaceans	Taiwan 1992 – now global	Nemavirus
Yellowhead disease	Marine shrimp	Thailand 1990 – now throughout Asia	Nidovirus
Taura syndrome	Marine shrimp	Ecuador 1992 – throughout the Americas and in Asia	Picornavirus

World farmed shrimp production



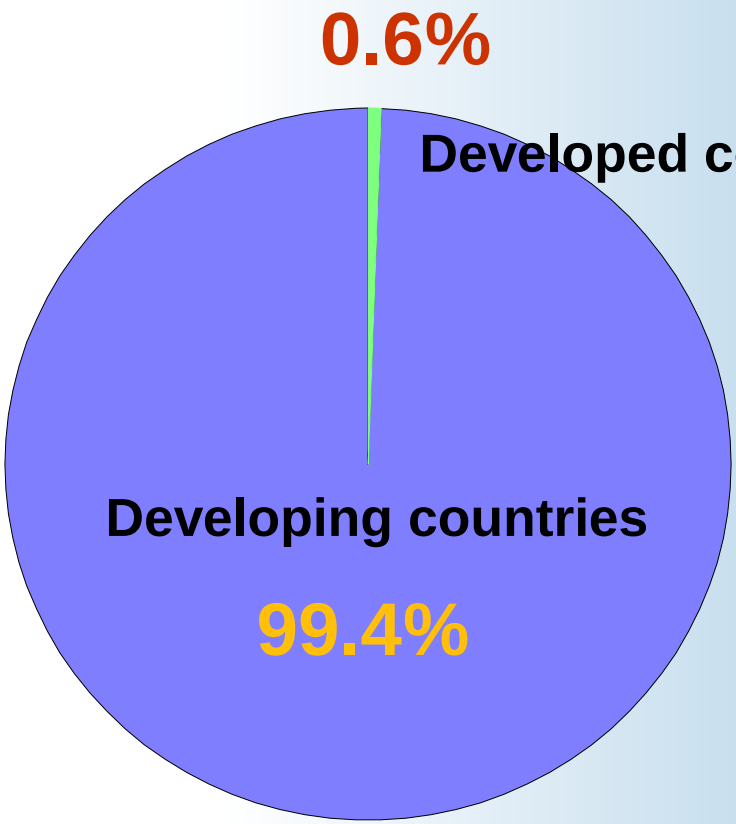
Source: FAO

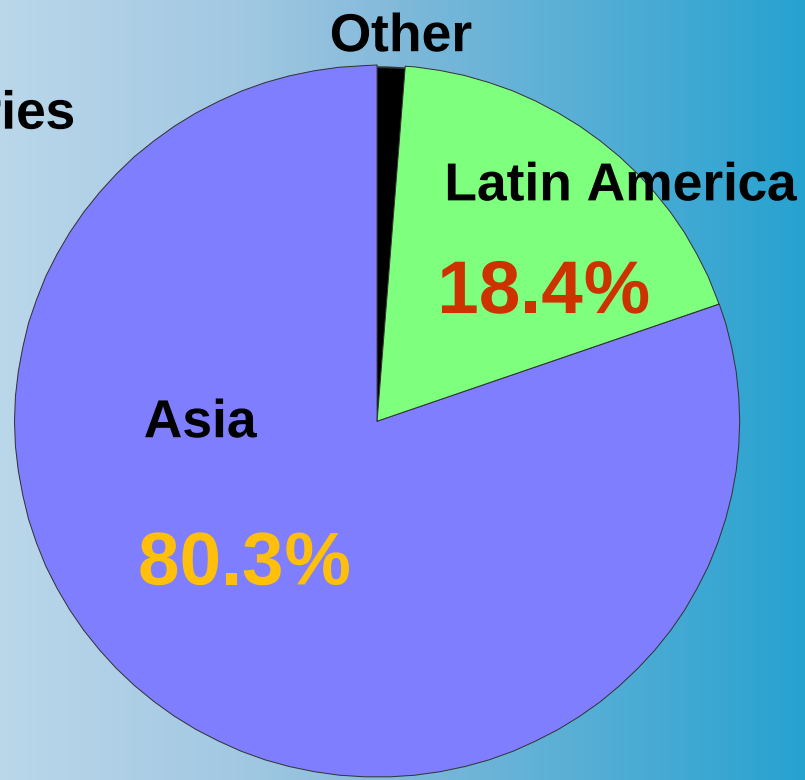
Rice-Shrimp Farm
Mekong, Vietnam


Dipisena, South Sumatra
- 4,500 ha
- 20,000 tonnes/year


Queensland, Australia

Geographic focus of farmed shrimp production





Aquaculture and disease emergence

Aquaculture is an important source of income and food in many developing countries

BUT

Aquaculture practices promote disease emergence:

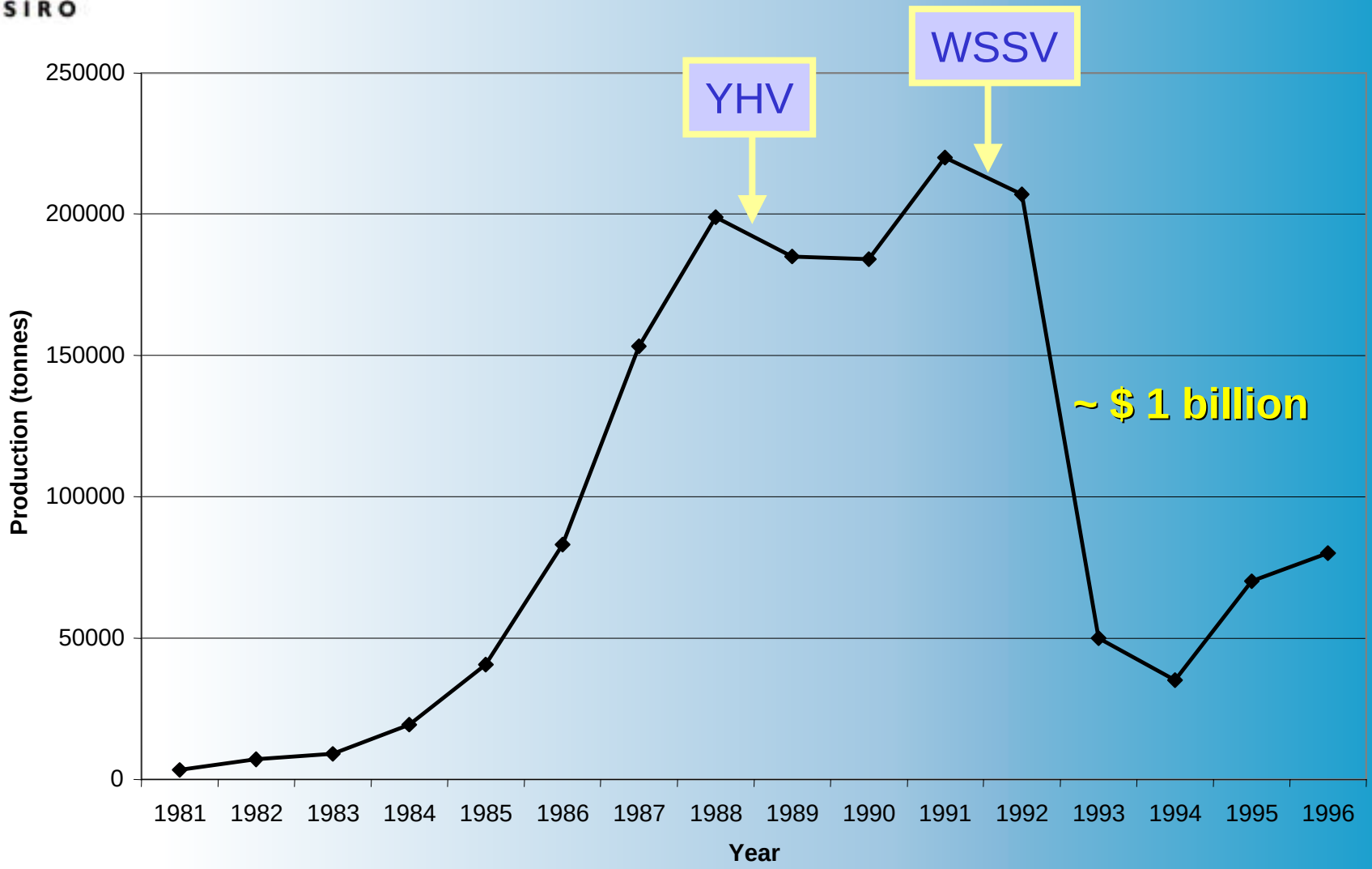
- animals are often cultured in an unnatural environment
- Animals are often stressed
- Animals are often in high stocking densities
- Trans-boundary movements of live animals is commonly occur

Impact of Viral Disease in Shrimp

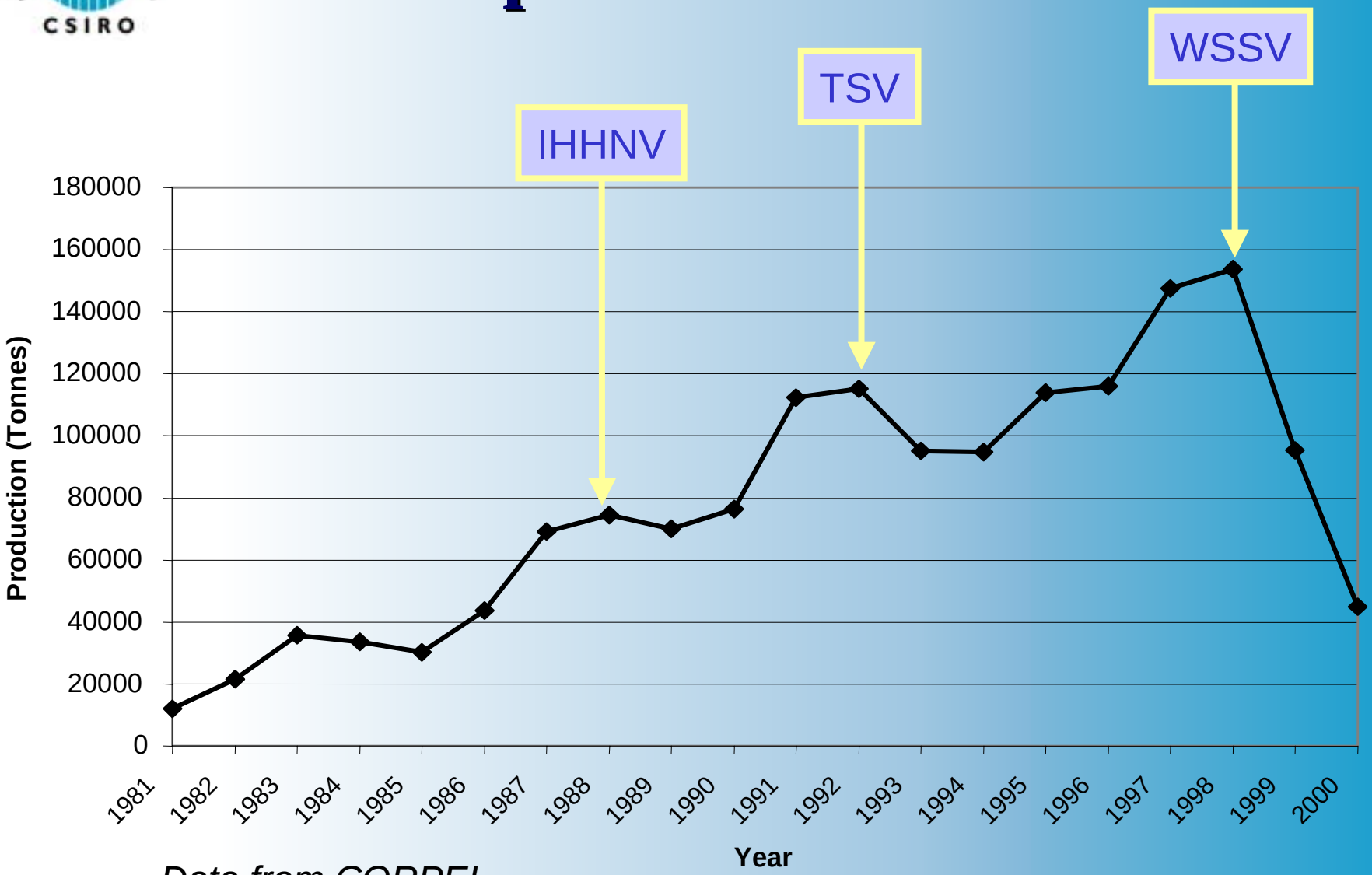
- Annual global loss $ 3 billion or 40% of production capacity *(Lundin, 1997)*
- TSV losses ~ $ 1-1.3 billion *(Lightner, 1995)*
- WSSV in Ecuador > $ 1 billion *(Anon 2000)*
- WSSV worldwide losses – $ 20-30 billion ? (lost production only)

- FMDV in UK estimated $ 5.7 billion in lost stock, lost trade, and lost tourism *(Countryside Agency, UK)*

Impact in China



Impact in Ecuador



Data from CORPEI

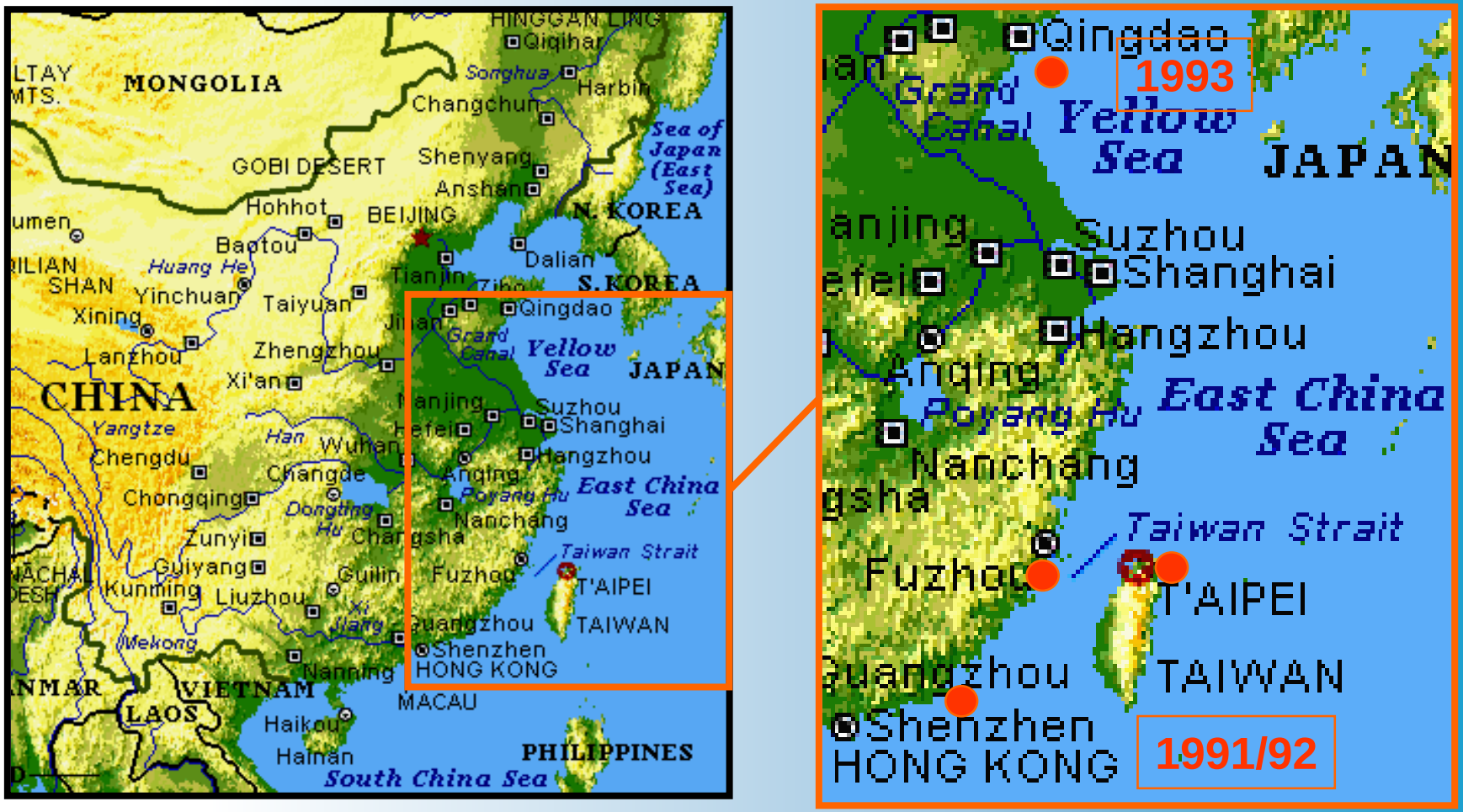
Socio-economic and environmental impacts of disease

- Direct loss of income and food security to subsistence-level farmers
- Loss of flow-on benefit to local communities
- Loss of export earnings to national economies
- Abandonment of rice farming in favour of unsuccessful shrimp farming
- Abandonment of “diseased” farms and establishment of new farms in environmentally sensitive areas

WHITE SPOT SYNDROME VIRUS

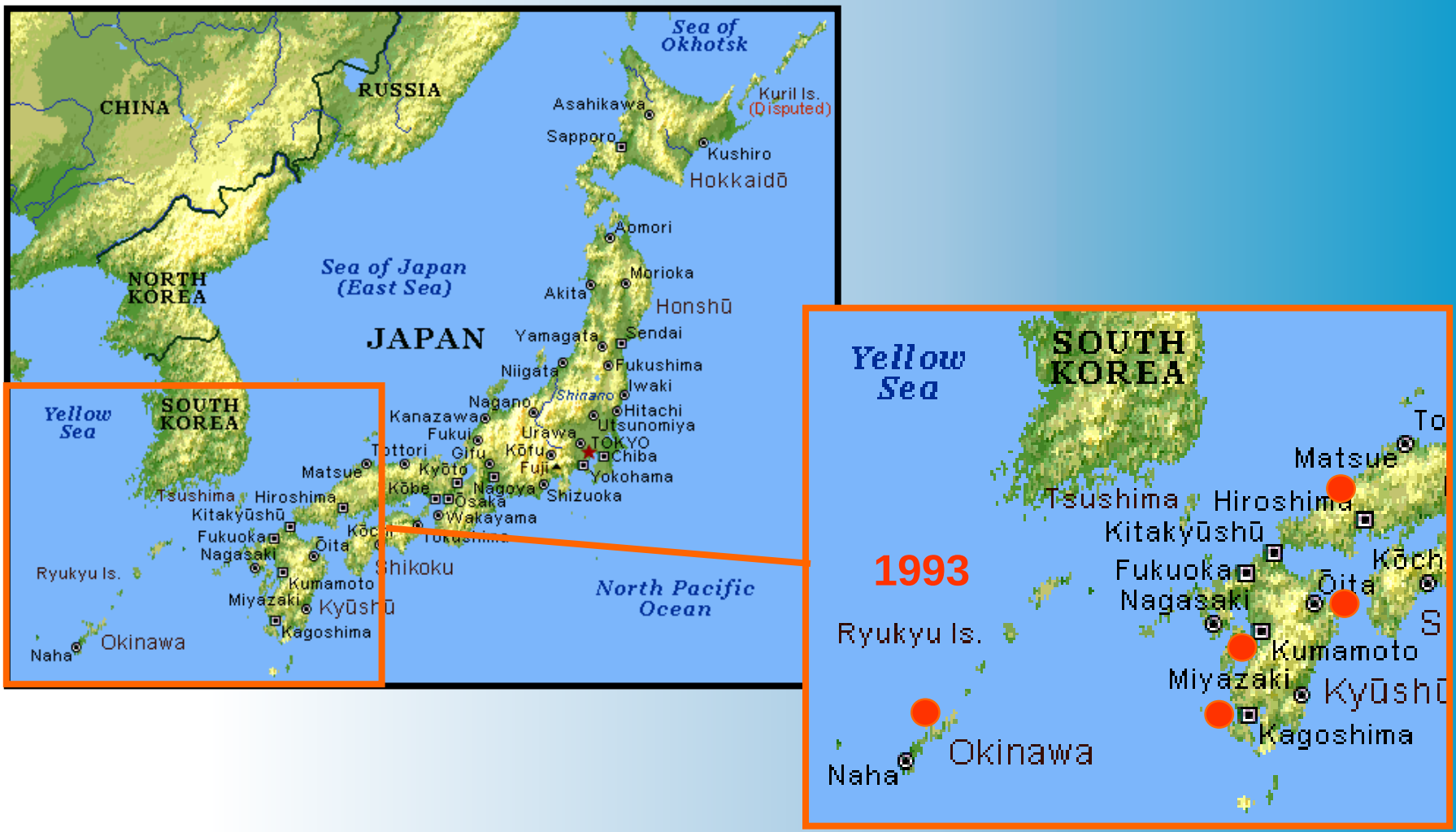
Global emergence from a single source

The Earliest Known Cases - Taiwan and Mainland China



Livestock Industries

Emergence in Japan

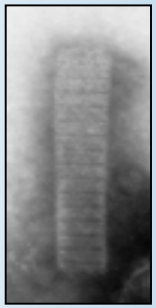


Explosive Emergence of WSSV in Asia

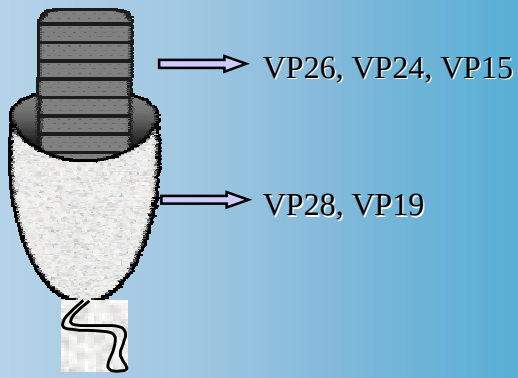
Emergence of WSSV in the Americas

Biological characteristics of WSSV

- Wide range of susceptible crustacean hosts
- Natural infection is usually chronic and low-level
- Transmission is vertical and horizontal
- Disease usually follows environmental stress
- Major target organs are on ecto-mesodermal origin (stomach, gills, lymphoid organ, cuticular epidermis, hepatopancreatic connective tissue)
- Disease is usually preceded by lethargy, lack of appetite and accompanied by reddening of the body and white calcifications on the carapace
- Death occurs rapidly after the appearance of signs

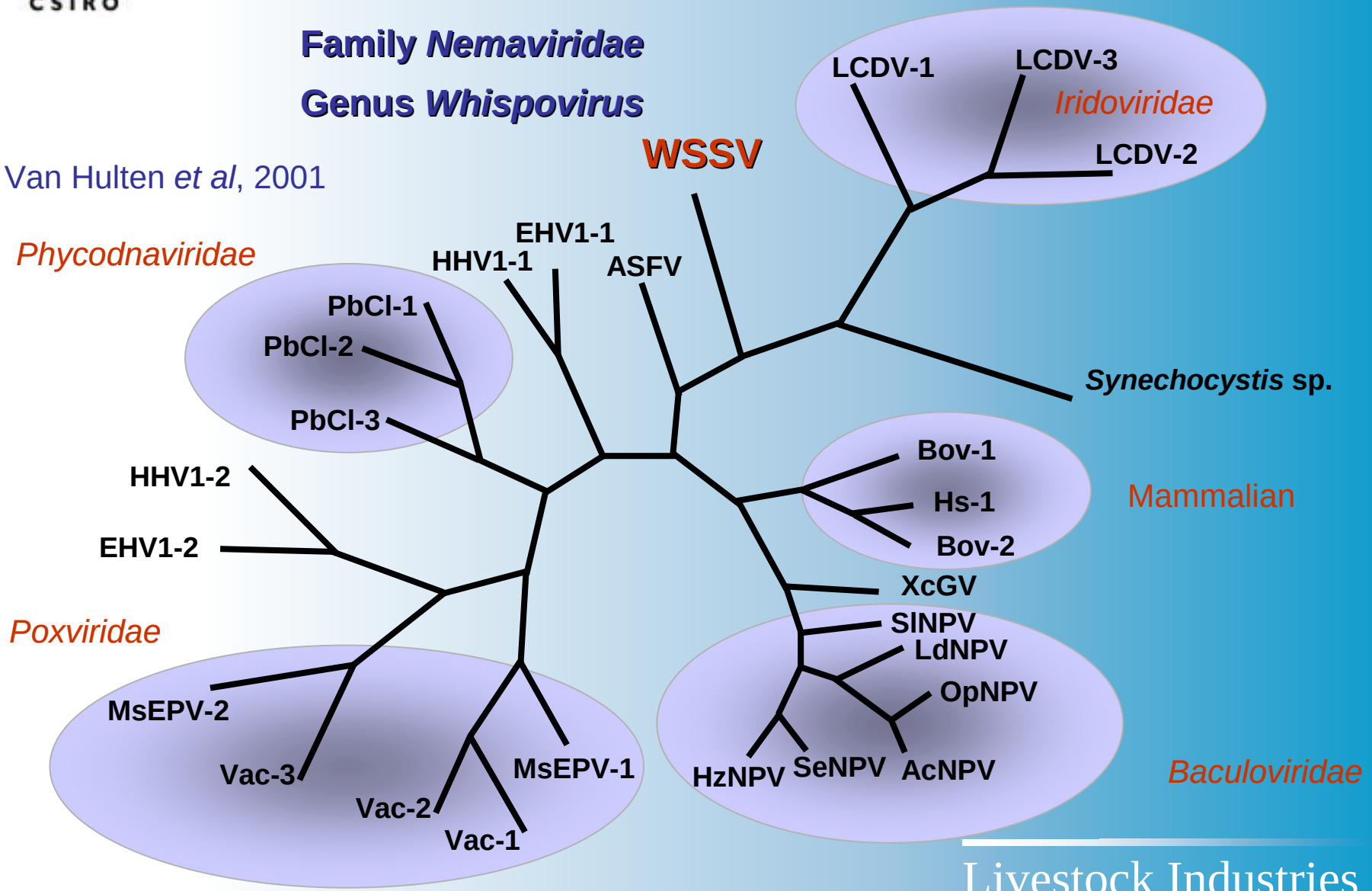


Van Hulten *et al*, 2000



- Large ovoid, enveloped, tailed virions (~ 130 x 280 nm)
- Helical nucleocapsid (~ 65 x 330 nm)
- Large circular dsDNA genome (305 kbp)
- Polypeptides Mr from 14,000 – 100,000
- Two major envelope proteins (VP28 and VP19)
- Three major nucleocapsid proteins VP15, VP24 and VP26)
- New Family *Nemaviridae* and new Genus *Whispovirus* proposed

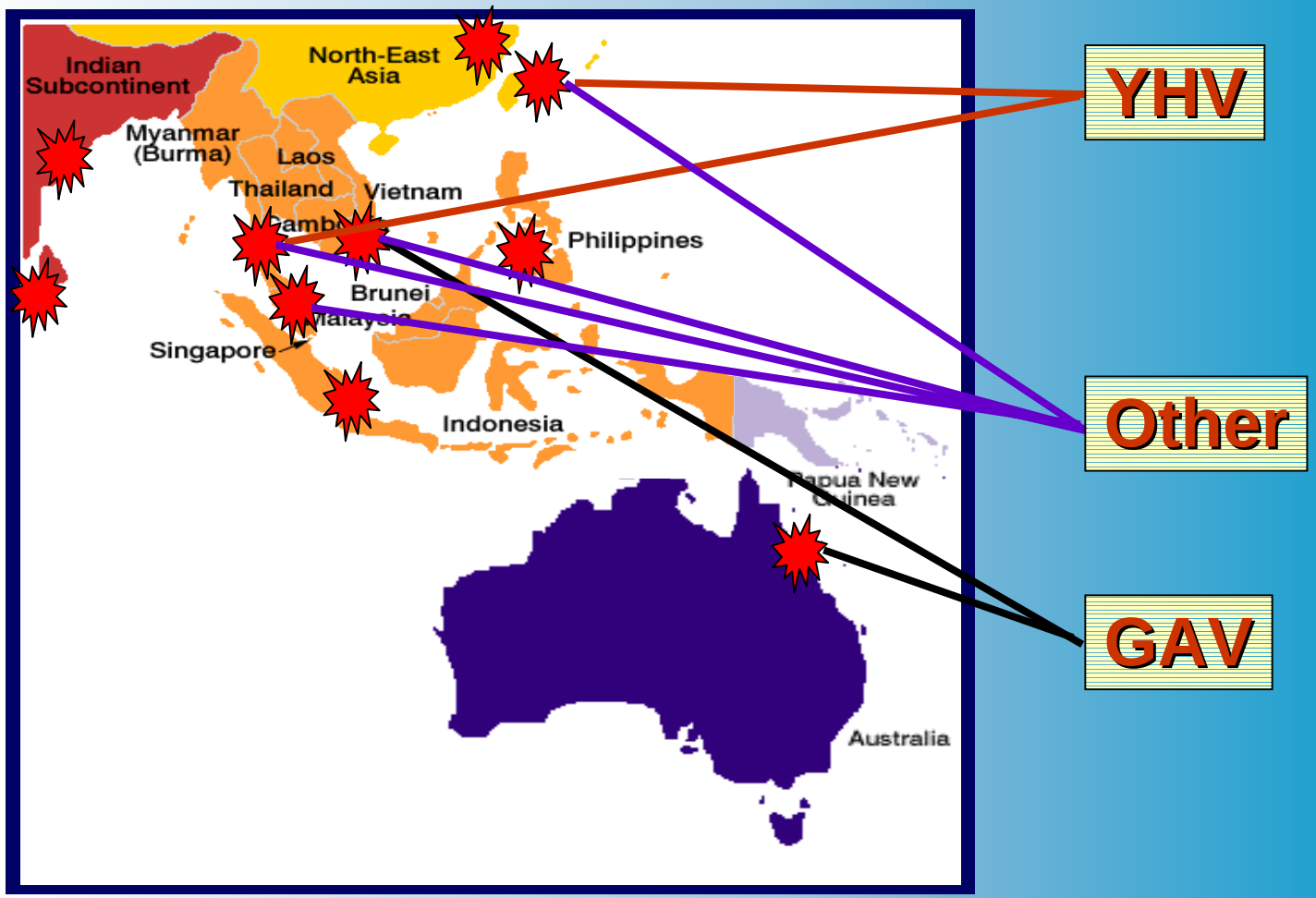
Phylogeny of protein kinase from large DNA viruses



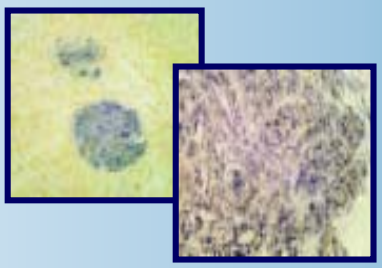
YELLOW HEAD COMPLEX

Environmental destabilization of natural host-pathogen relationship

Reported distribution of yellowhead complex viruses

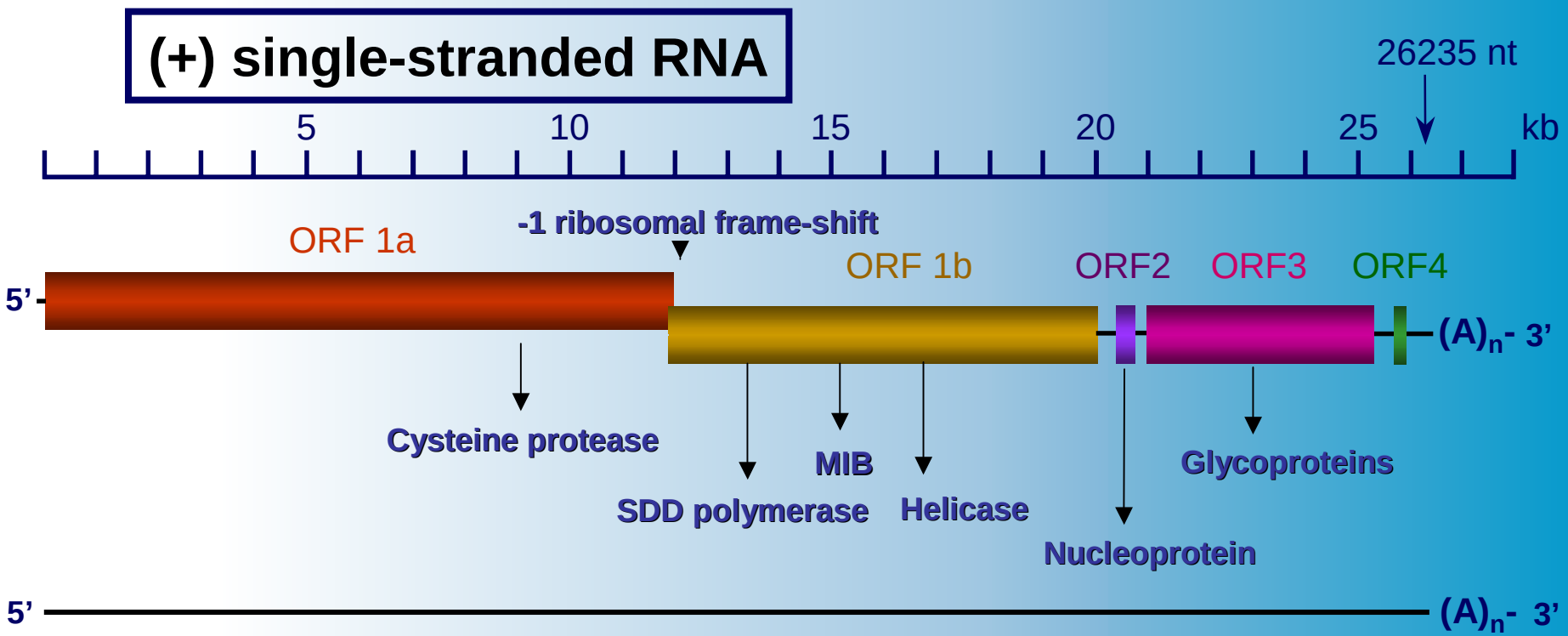


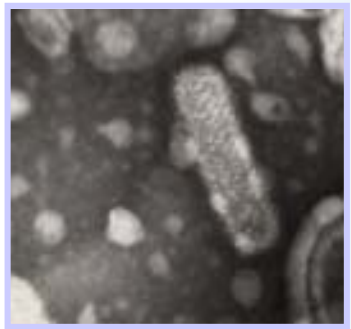
Biological characteristics of yellowhead viruses



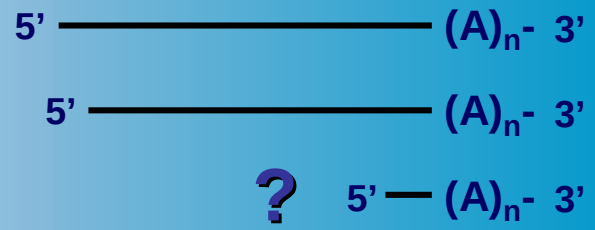
- Limited natural host range – perhaps species-specific
- Natural infection is usually chronic and low-level
- Prevalence of natural chronic infection is often high
- Infects lymphoid organ, connective tissues and gonads
- Transmission is vertical and horizontal
- Disease appears to be related to environmental stress
- Disease is usually preceded by lethargy, lack of appetite and accompanied by reddening or yellowing of the body
- Death rapidly follows the appearance of gross signs

Molecular characteristics of GAV

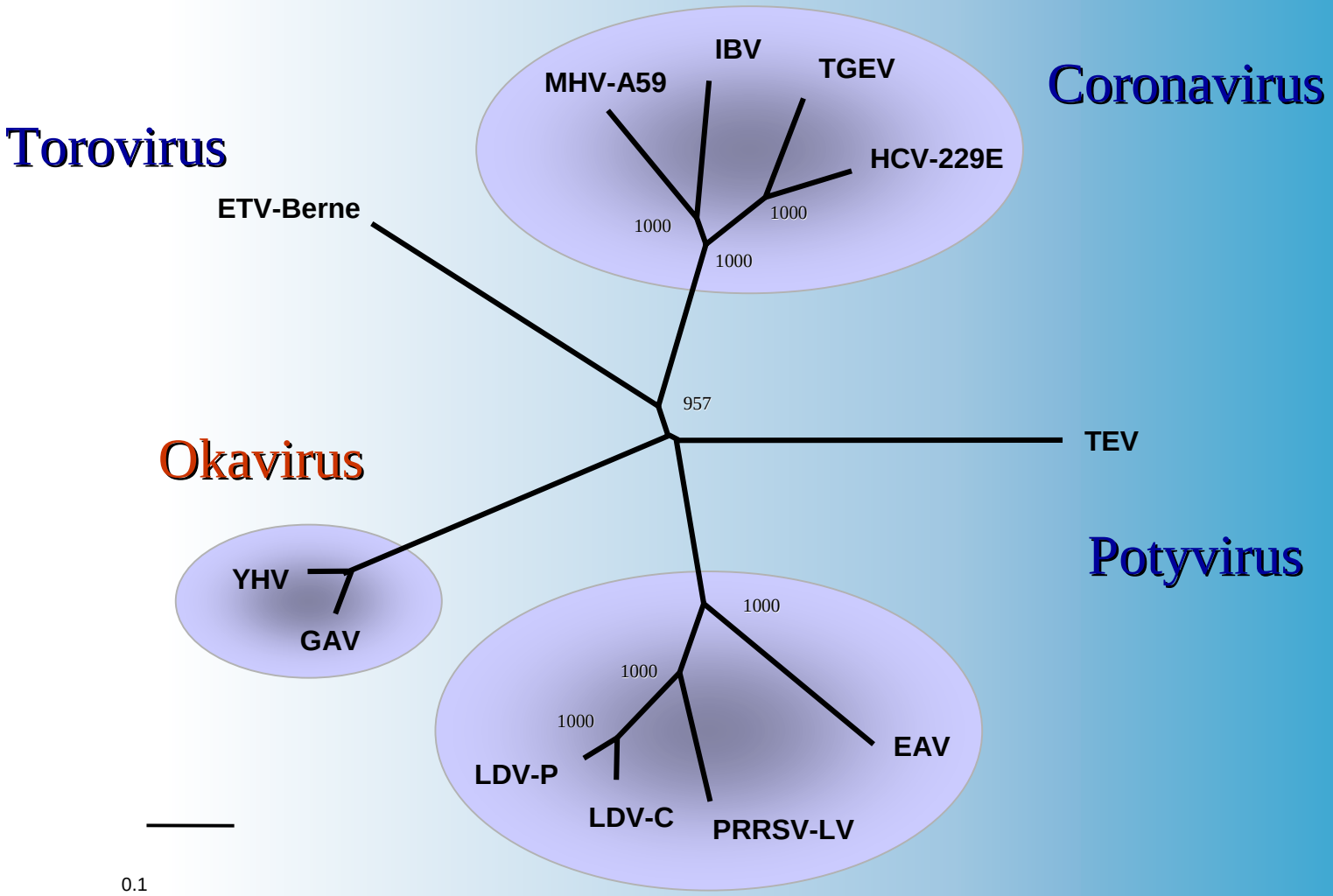




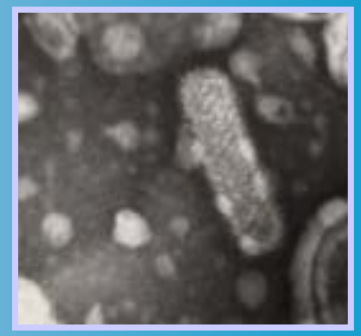
Nested sub-genomic RNAs



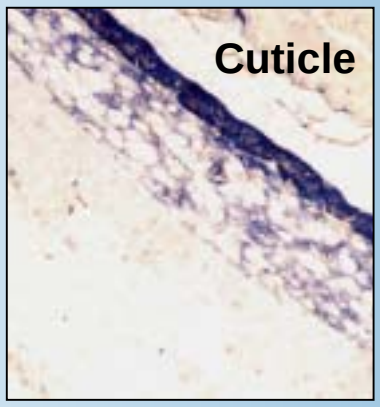
Phylogeny of the polymerase domain

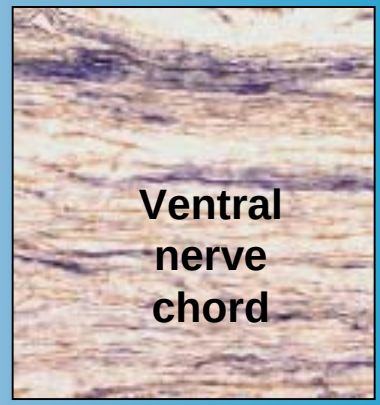


Classification of YHV and GAV

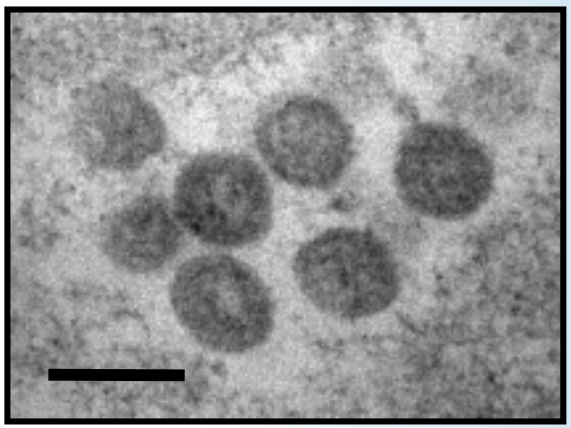


Order	Family	Genus	Species
Nidovirales	*Coronaviridae*	*Coronavirus*	***Human coronavirus***
			Avian infectious bronchitis virus
			Mouse hepatitis virus
			Duck hepatitis virus
		Torovirus	***Berne virus* (equine)**
			***Breda virus* (bovine)**
	Arteriviridae	*Arterivirus*	***Equine arteritis virus***
	(Roniviridae)	*(Okavirus)*	**YHV**
			GAV





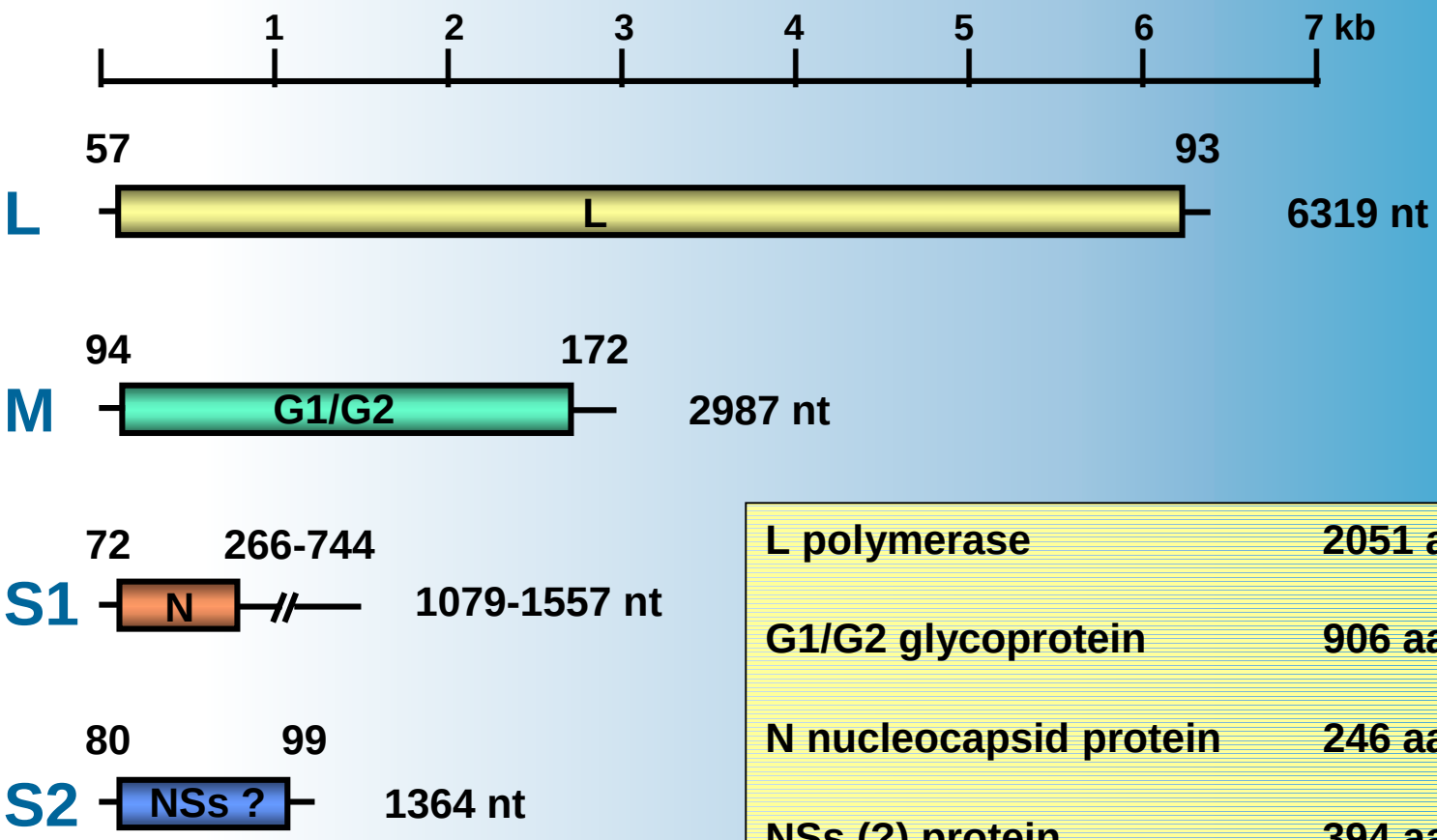
MOURYLIAN VIRUS



100 nm

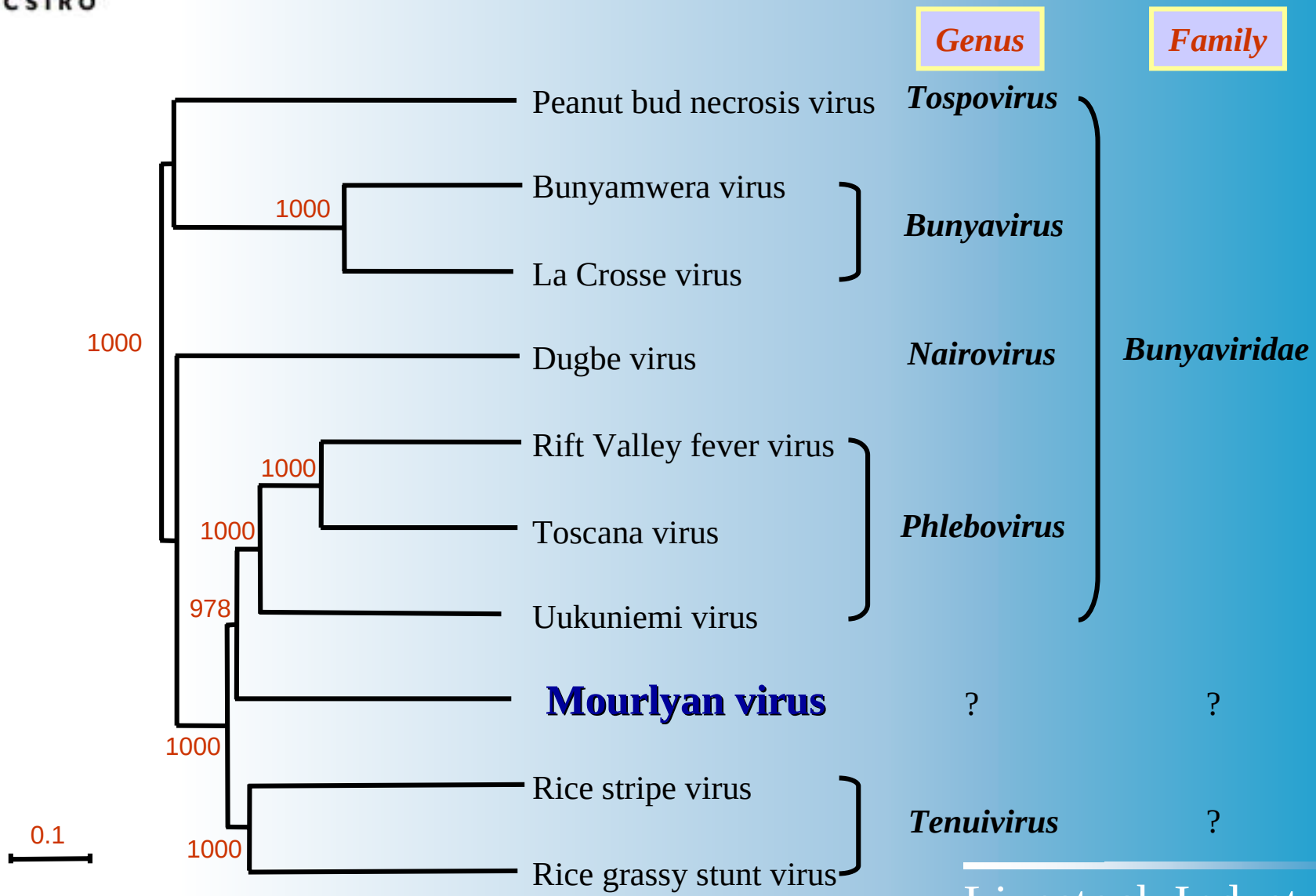
- Infects tiger and Kuruma prawns
- Causes gut-and-nerve syndrome
  - Hyperplasia of the epineurium
  - Infects midgut cuticular epithelium
- Slowly progressing mortalities
- Agent is a bunya-related virus

MV(-)ss RNA genome segments

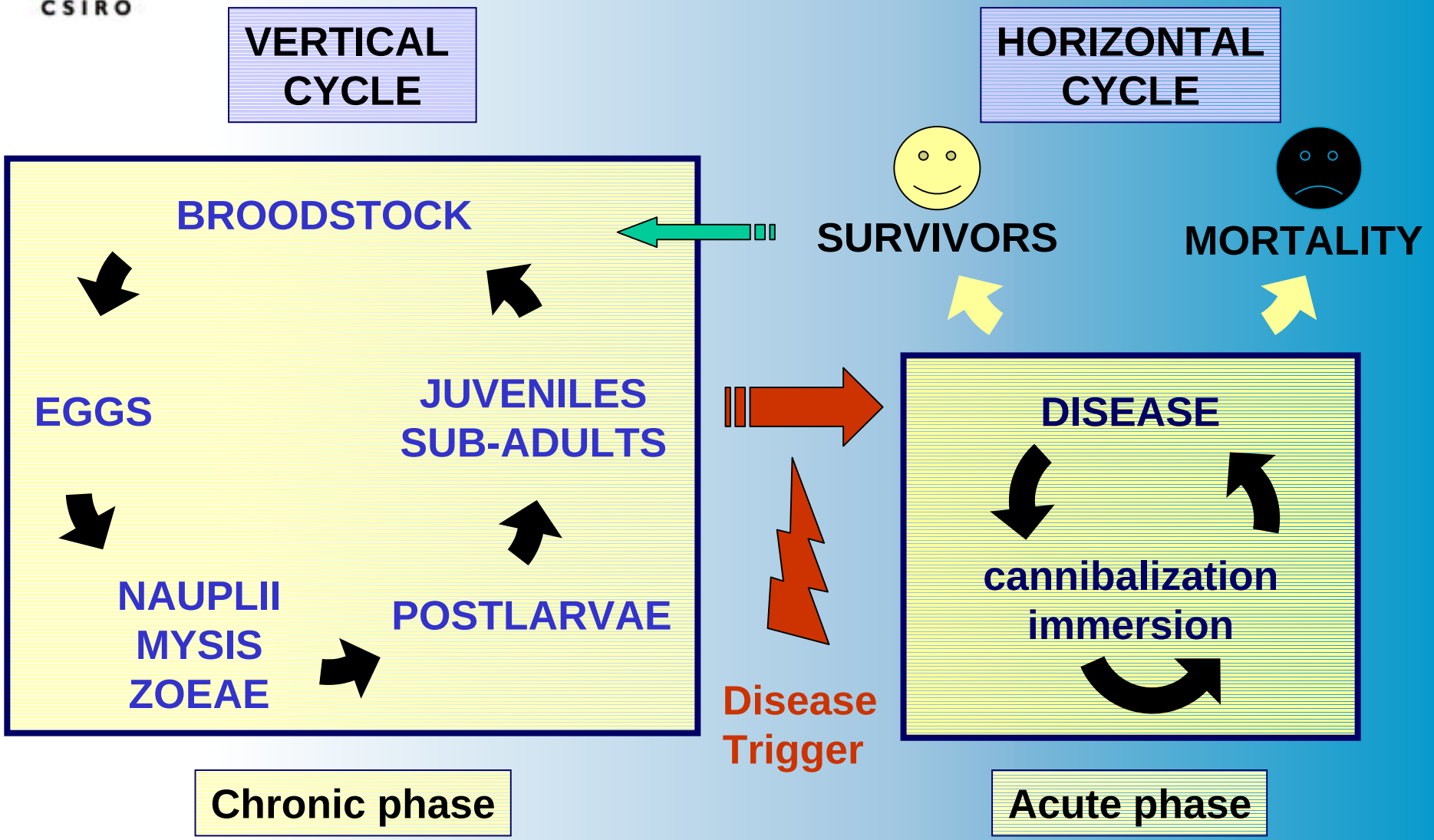


L polymerase	2051 aa (233 kDa)
G1/G2 glycoprotein	906 aa (99.2 kDa)
N nucleocapsid protein	246 aa (27.4 kDa)
NSs (?) protein	394 aa (45.6 kDa)

Phylogenetic analysis of MV L protein sequence



Biological cycle of major shrimp viruses



Disease control and prevention

- Elimination of infected seed – PCR screening in hatcheries
- Reduction of stress on farm – lower stocking densities, control of water quality
- Exclusion of crustacean carriers – screening water supply, crab fences
- Vaccines – little evidence of adaptive immunity in invertebrates
- SPF and SPR stock – available for some species through breeding and genetic improvement programs
- **Subsistence-level farmers presently have very limited capacity to implement these measures**
- **Regional cooperation in restricting trans-boundary movement of aquatic animals and pathogens is essential**

Summary

- Food security - a key element of health and welfare for developing economies and is an essential prerequisite for peace and prosperity
- Emerging infectious diseases of food animals and field crops are impacting significantly on global food production and the human condition
- Shrimp farming is a new, rapidly expanding industry that provides extraordinary opportunities for disease emergence
- Recently emergent viral pathogens in shrimp are causing economic loss and social and environmental impacts on a massive scale
- Many of the pathogens are new to science and will be classified as new viral taxa at the genus or family level

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