

Environmental (& “other”) Applications (of Nuclear Techniques)

UK Nuclear Physics Summer School

Bristol 26/8 – 7/9 2013

#uk_npss

Iain Darby

NAPC-PH/NSIL



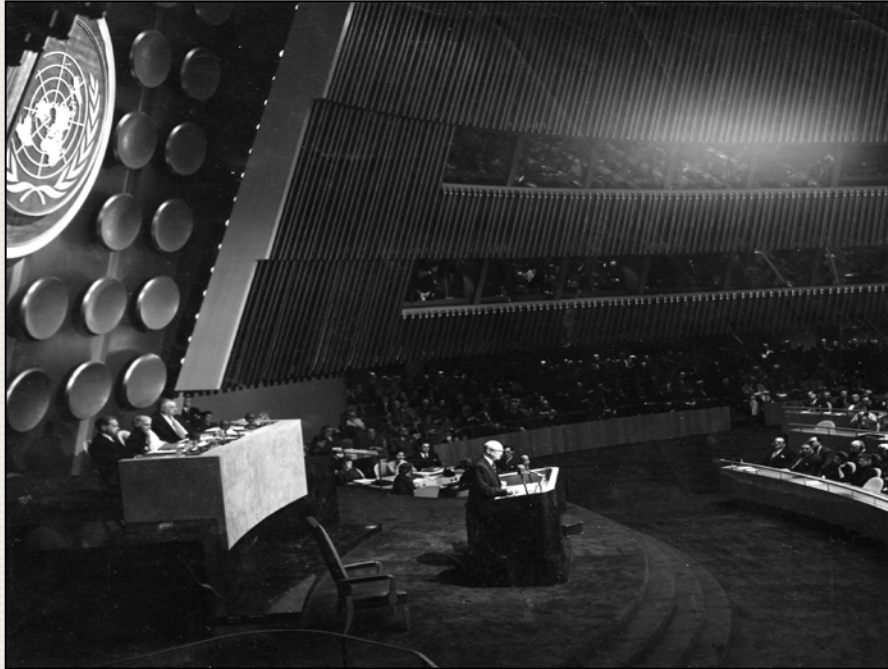
IAEA

International Atomic Energy Agency

Lectures Overview

- Part I – Whistle stop tour and broad horizons
- Part II – In-situ measuring
- Part III – The changing environment
- (Part IV...possibly) – Cultural Heritage

IAEA Statute, Article II



U.S. President Dwight D. Eisenhower addresses
the U.N. General Assembly, 8 December 1953
Atoms for Peace Speech

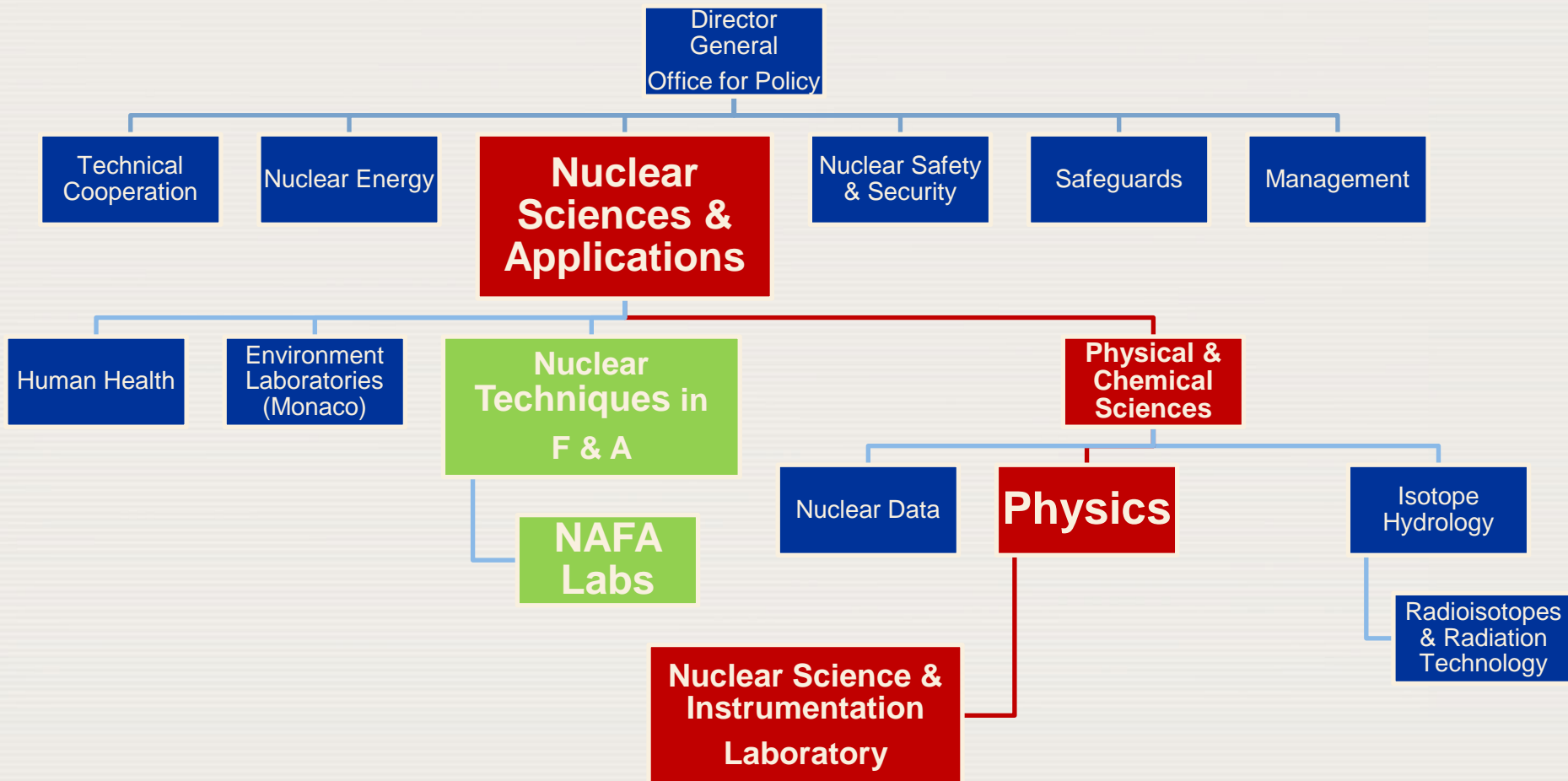


- The Agency shall seek to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world.

IAEA by the numbers

- Created in **1957**
- **158** Member States
- **2400+** Staff
- **1** Headquarters (Vienna)
- **2** Liaison Offices (New York, Geneva)
- **2** Regional Safeguards Offices (Tokyo, Toronto)
- **3** International laboratories and research centres
(Seibersdorf, Monaco, Trieste)

Organisation



Discover the IAEA

<http://www.youtube.com/watch?v=qf81dNyusIY>

Uploaded on Mar 4, 2011

The International Atomic Energy Agency works to maximize the contribution of nuclear technology to the world, while verifying its peaceful use.

The IAEA assists its member states with nuclear power programmes, helps to combat the threat of nuclear terrorism and employs nuclear safeguards to deter the diversion of nuclear material for military purposes.

From its headquarters in Vienna and laboratories in Monaco and Seibersdorf, Austria, the IAEA also uses nuclear science to help countries tackle issues such as food security, water resource management, environmental pollution and cancer.

This film gives viewers an insight into the fascinating world of the IAEA.



Nuclear Sciences & Applications (NA)

- *“to enhance (the IAEA’s) role in promoting the advantages of nuclear technology and applications where they have an added value for addressing basic human and socio-economic development needs and in promoting capacity building in Member States”*

- *In the Areas of:*

Food Security

Human Health

Cancer Control

Water Resources Management

Industrial Applications

Environmental Protection

Nuclear Sciences & Applications (NA)

Fighting a global cancer epidemic



Improving the diagnosis and treatment of disease



Promoting food security and sustainable economic development



Understanding and protecting the environment



Making more, and cleaner water available to more people



Providing knowledge and expertise for science and industry



Food & Agriculture

Working towards global **food security** in partnership with **FAO**

- Supporting agricultural **soil and water management**
- Developing better **crop varieties**
- Reducing risk of transboundary **animal disease**
- Controlling insect **pests**
- Promoting traceability for **food safety and quality**



Food for the Future

<http://www.youtube.com/watch?v=47N66-lny2c>

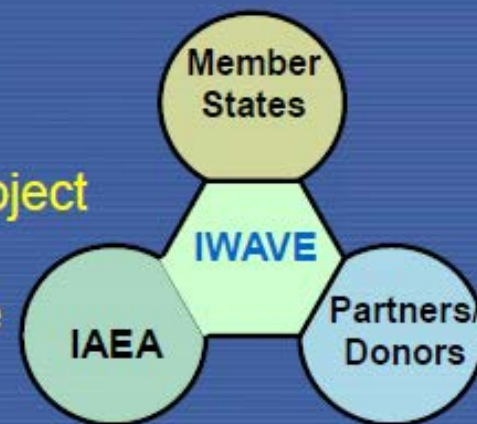
Published on Sep 18, 2012

The High Andes of Peru, the busy streets of Jakarta and the dusty Cameroon bush -- all very different places, in diverse parts of the world, with one thing in common: the people here are all benefiting from nuclear science and the support of the IAEA to produce and protect food and make it safer.

Water Resources

Enhancing **sustainable management** of water resources

- **Mapping** of groundwater by using radioisotopes
- Assessing surface and groundwater via the **IAEA Water Availability Enhancement (IWAVE)** project
- Building Member States capacity to be **sustainable** and **self-reliant** in isotope hydrology
- Ensuring availability of **innovative techniques**



Water Matters

<http://www.youtube.com/watch?v=PMOZiC-kyNQ>

Water Matters: Making a Difference with Nuclear Techniques

Uploaded on Sep 19, 2011

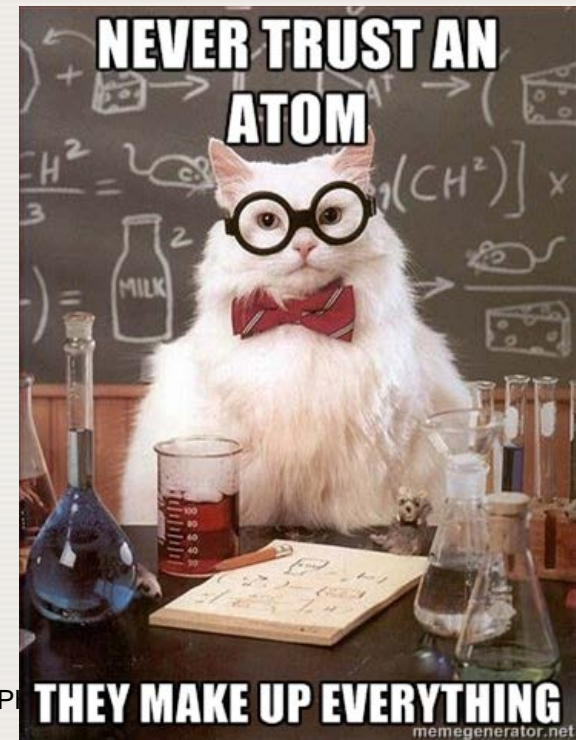
For over 50 years, the IAEA has promoted the use of nuclear techniques to tackle some of the earth's most pressing water challenges. The Agency conducts over 100 projects in around 90 countries that apply nuclear techniques in the fields of water resources assessment, agricultural water management and marine pollution control.

Regarding Isotopes

Atoms of the same element with differing mass

The nuclei differ by the number of neutrons

- e.g. Carbon
 - ^{12}C ~ 98.9%
 - ^{13}C ~ 1.1%
 - ^{14}C – miniscule
- Considering stable isotopes only



Information Delivered by IRMS

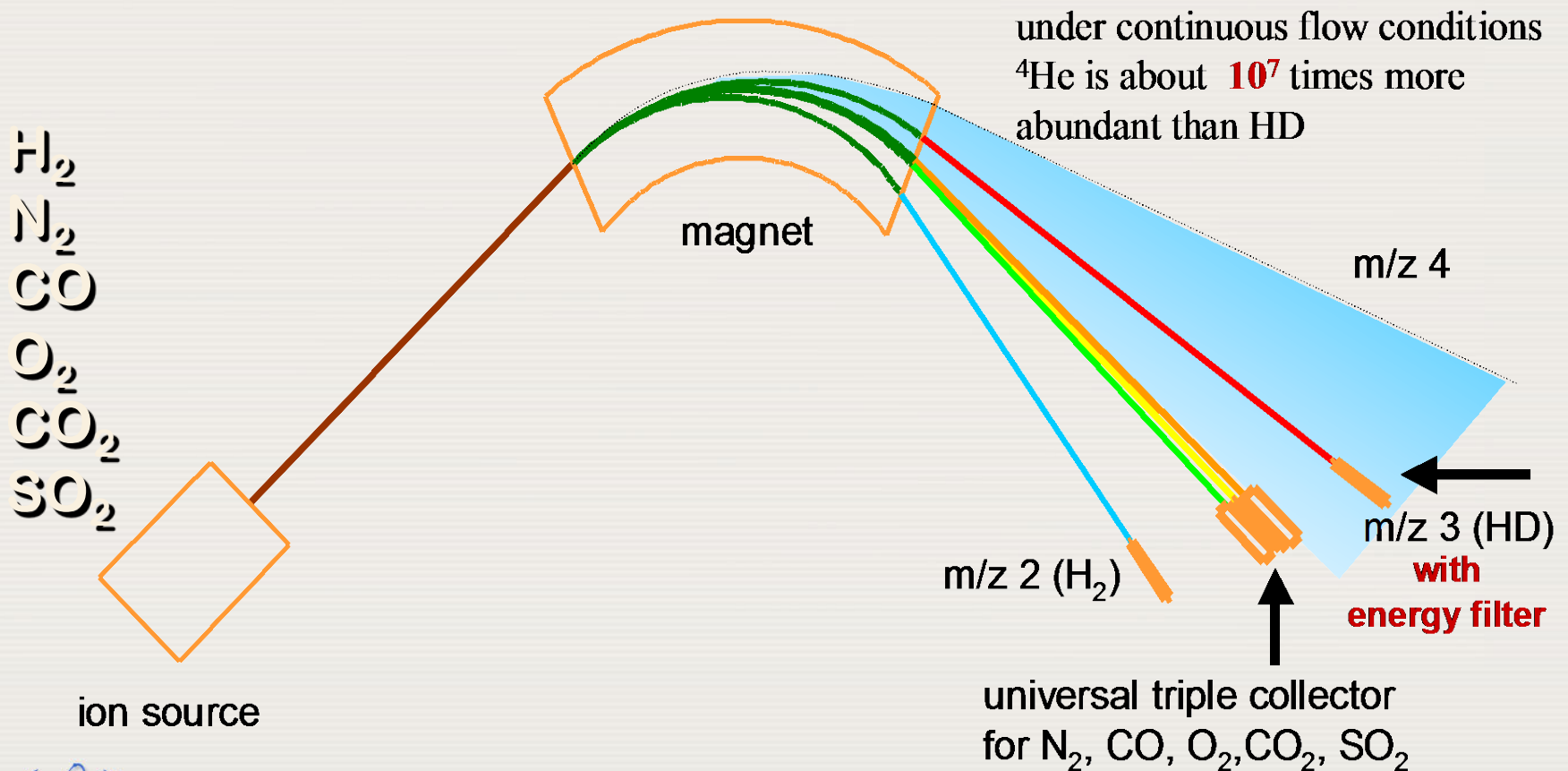
- Precise Isotope Ratios of:

- Element Minor Isotope Natural Abundance [%]

• Hydrogen	^2H (D)	0.01557
• Carbon	^{13}C	1.11140
• Nitrogen	^{15}N	0.36630
• Oxygen	^{18}O	0.20004
• Sulfur	^{34}S	4.21500

This is where the information is

Multi Collectors for Simultaneous Detection



Notation

- δ -values - Absolute abundance's and absolute ratios of minor isotopes not accurately determined
- Measure ratio of sample relative to a standard - report as delta value in units of per mille (‰)

$$\delta = \left[\frac{R_{sample}}{R_{reference}} - 1 \right]$$

- International reference standards

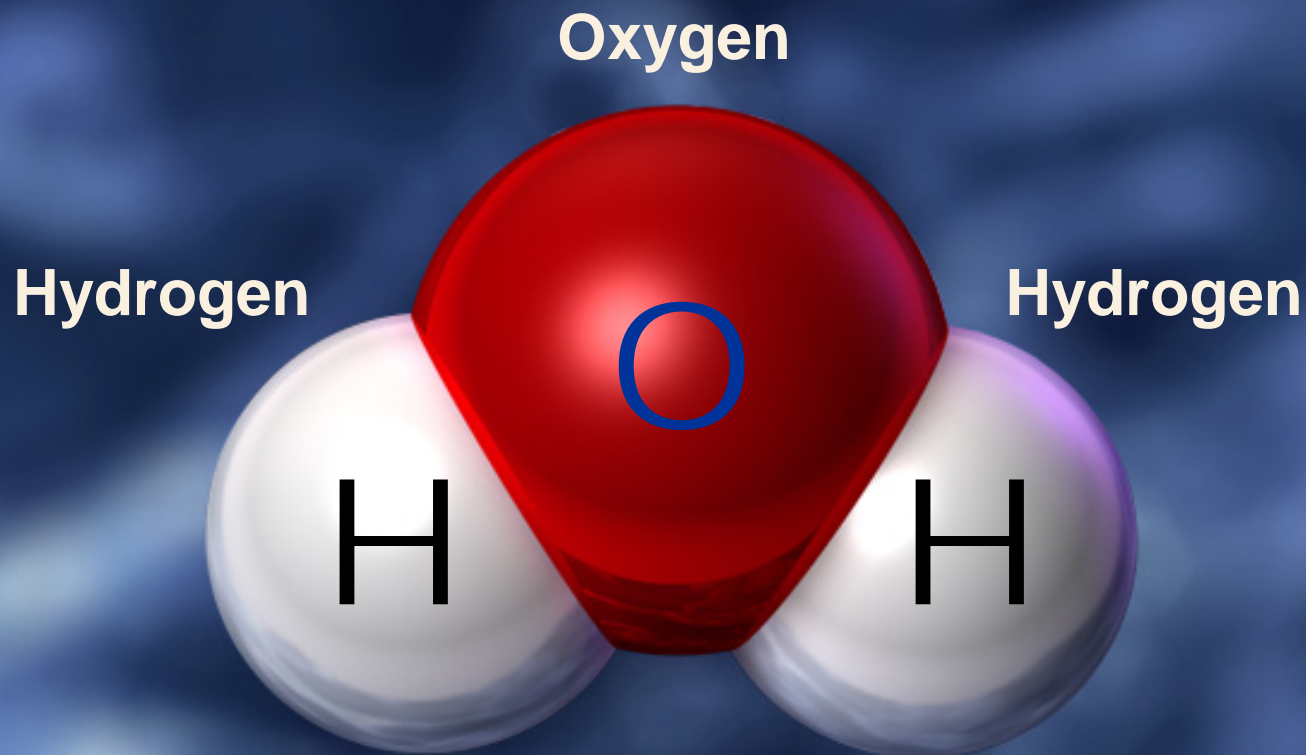
N – air; C – VPDB; O, H – VSMOW, S - CDT

Forensic Isotope Ratio Mass Spectrometry (FIRMS)

- Isotope fingerprinting
- Conventional chemical analysis – identification and quantification.
- IRMS - determine relationships or pathways
- **Isotopic composition is unique to the origin and history of the substance**

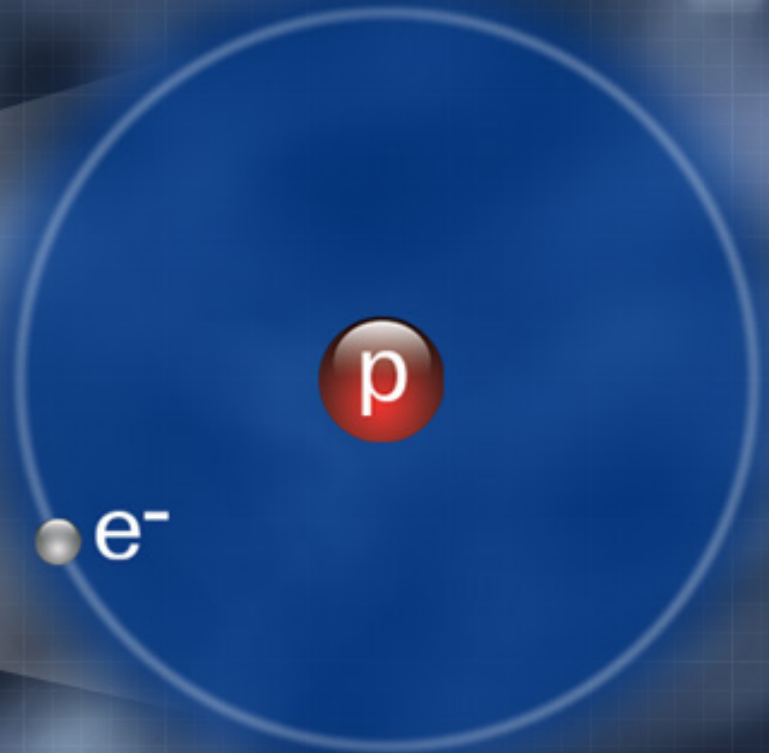
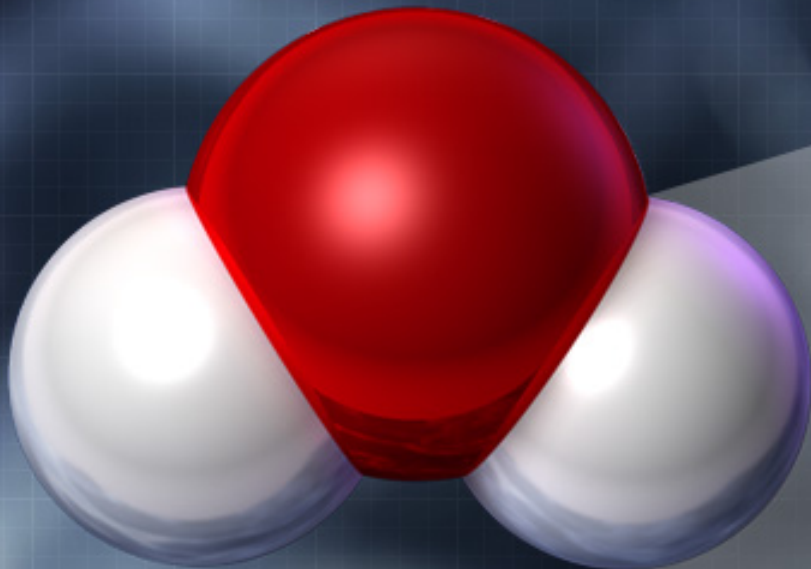


WATER



Hydrogen Isotopes - Protium

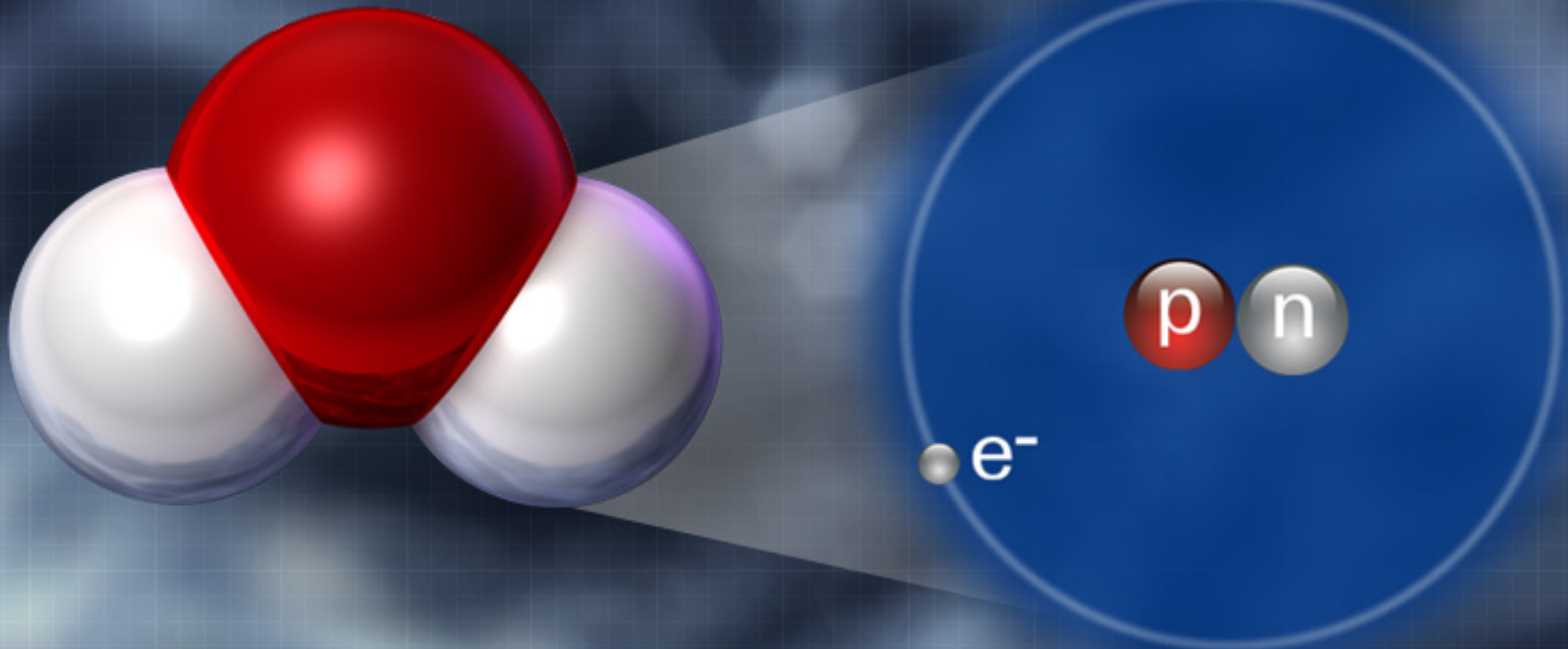
- ${}^1\text{H}$, stable



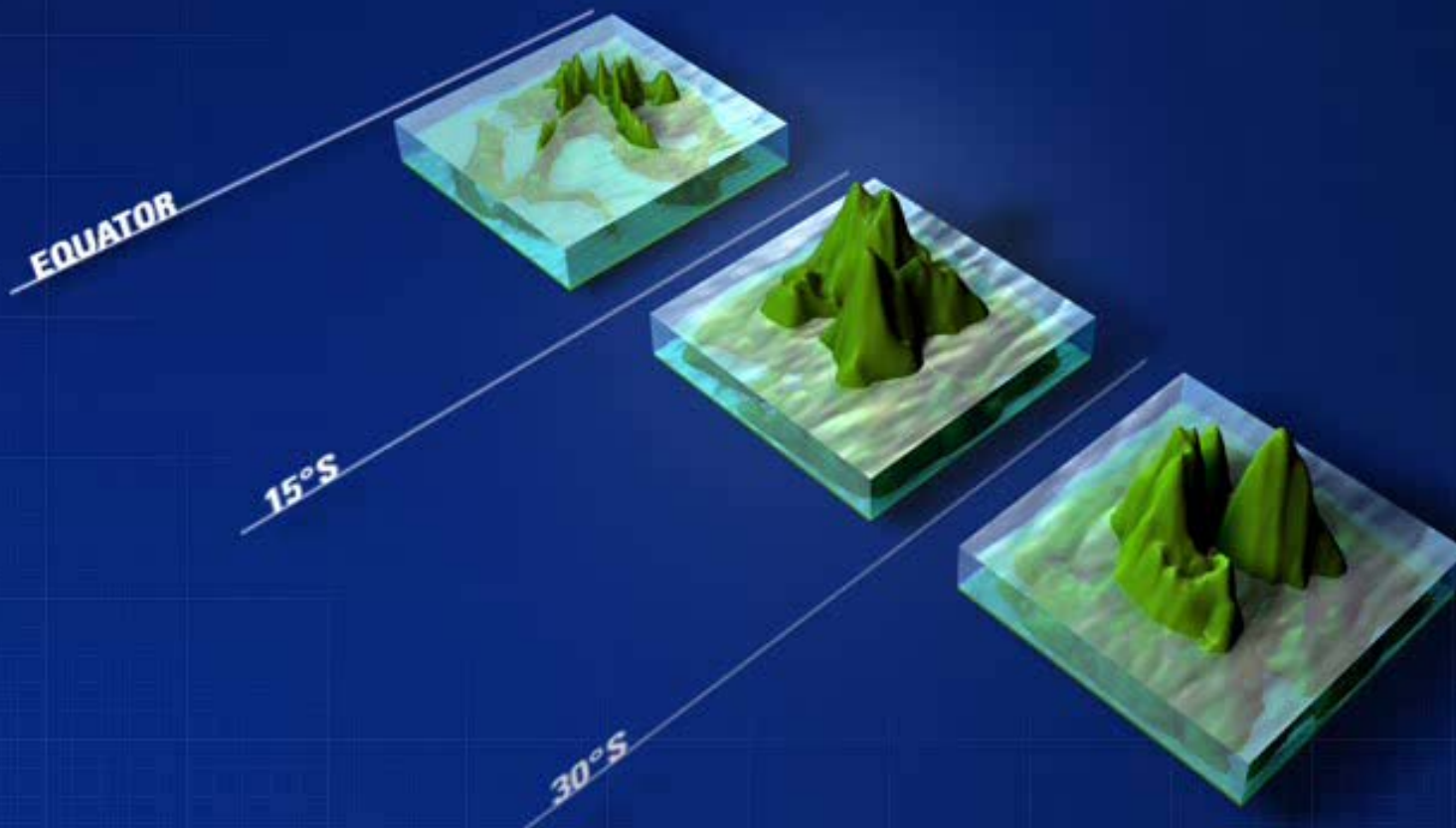
Abundance: 99.985%

Hydrogen Isotopes - Deuterium

- ^2H , or D, stable



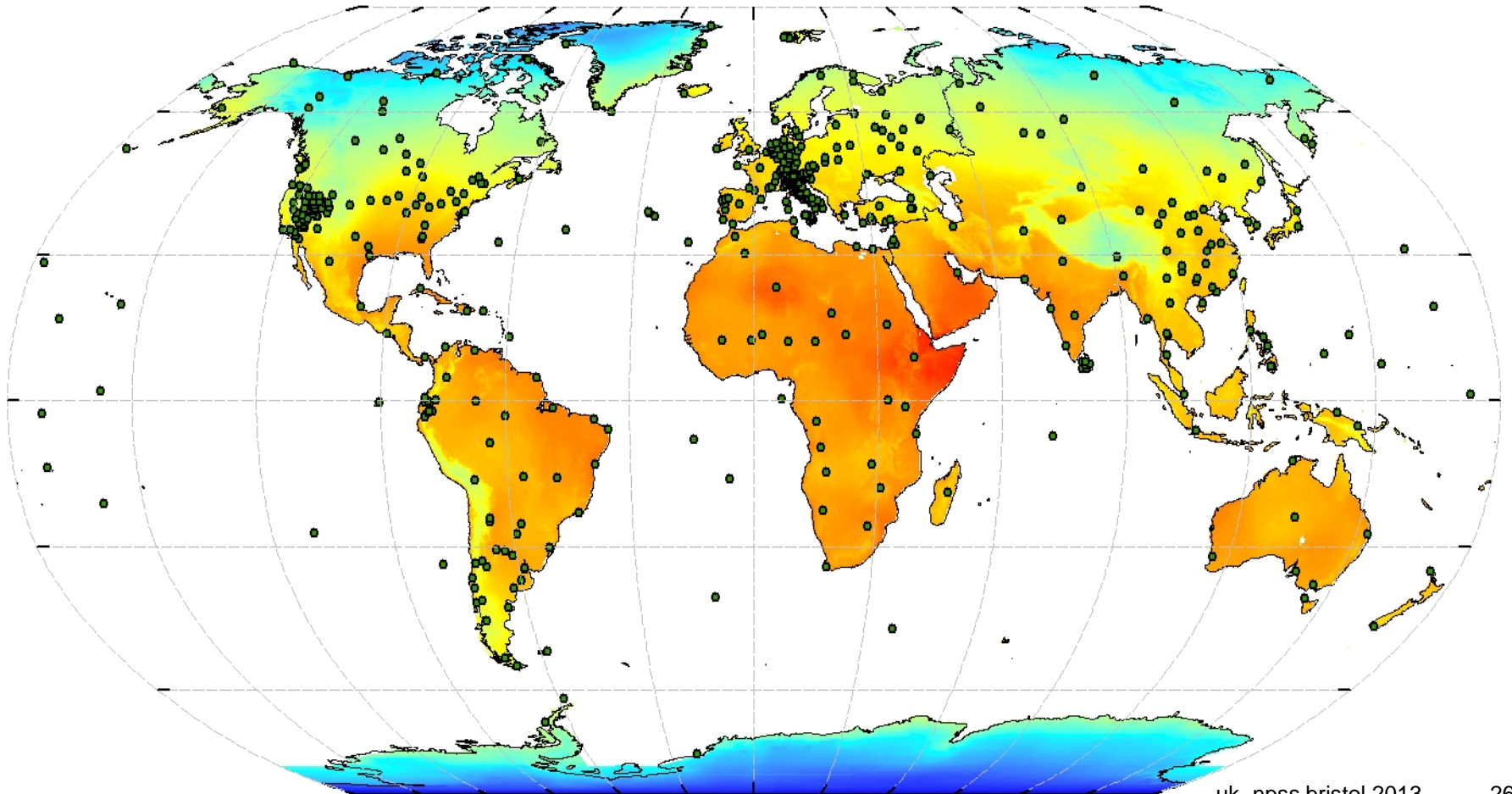
Abundance: 0.0026–0.0184%







Global Patterns





THE PAINTED APPLE MOTH

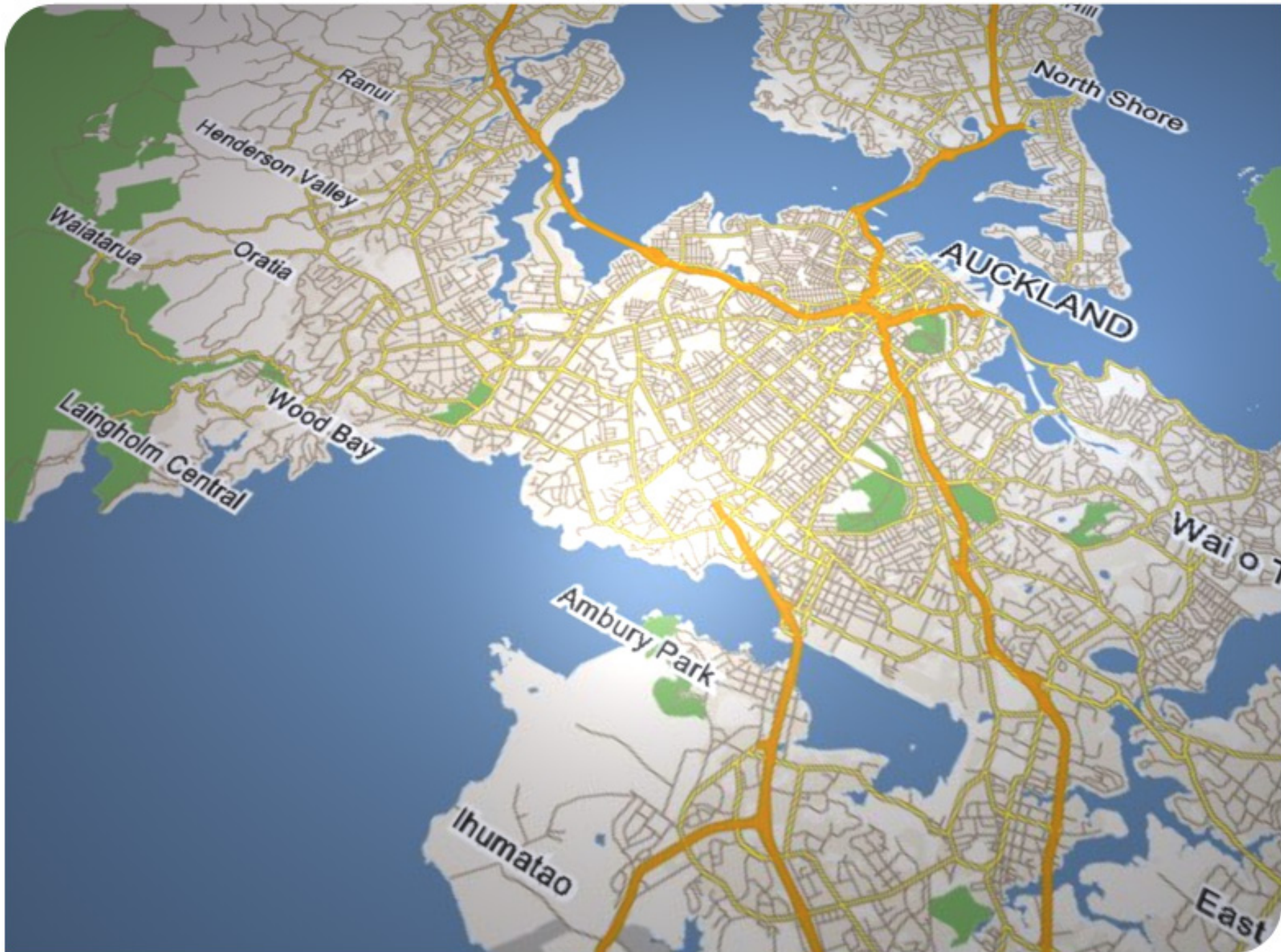


Teia anartoides

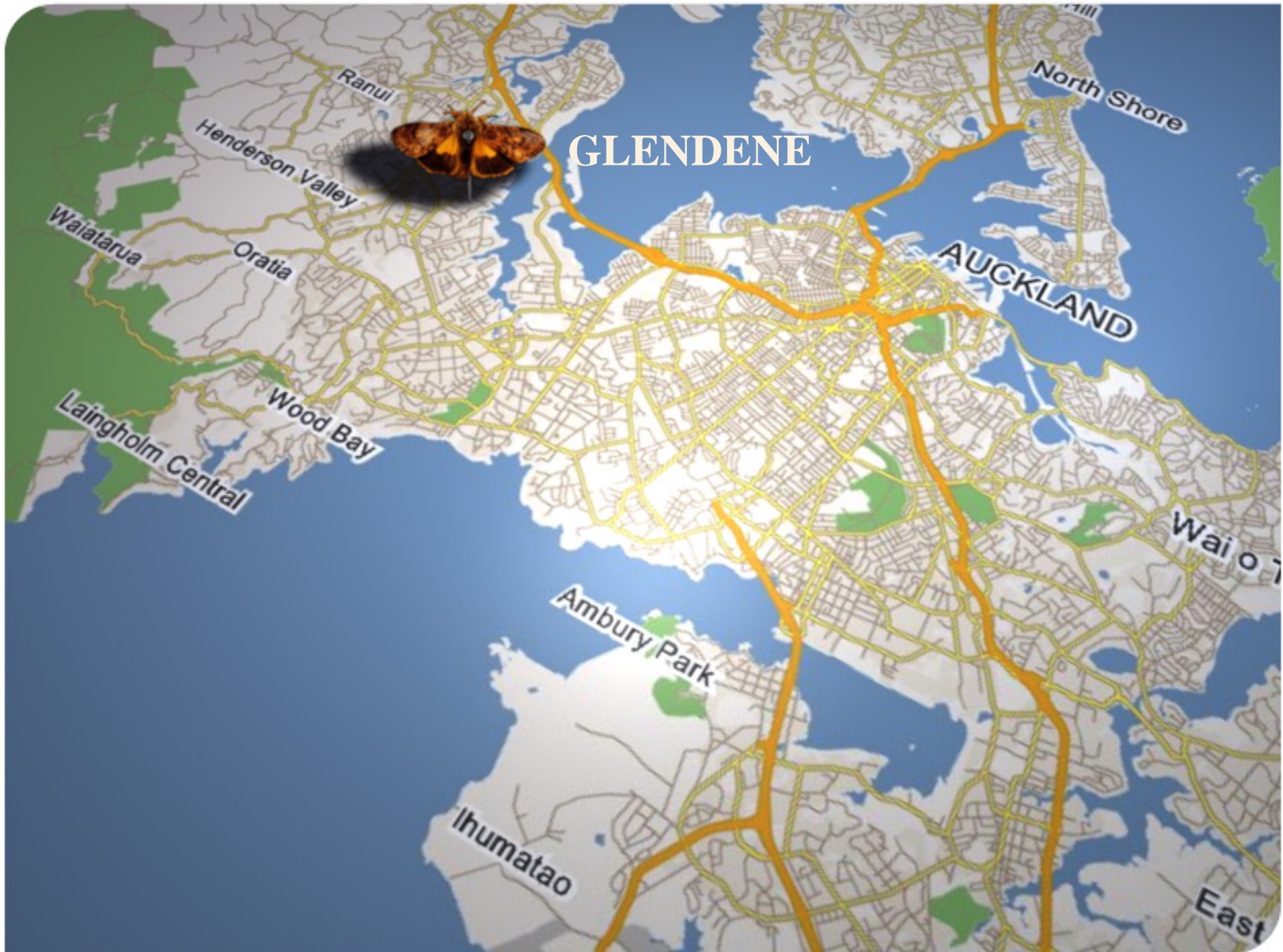
“This pest poses a serious threat to New Zealand gardens, crops, forests, native bush and the communities that depend on them.”



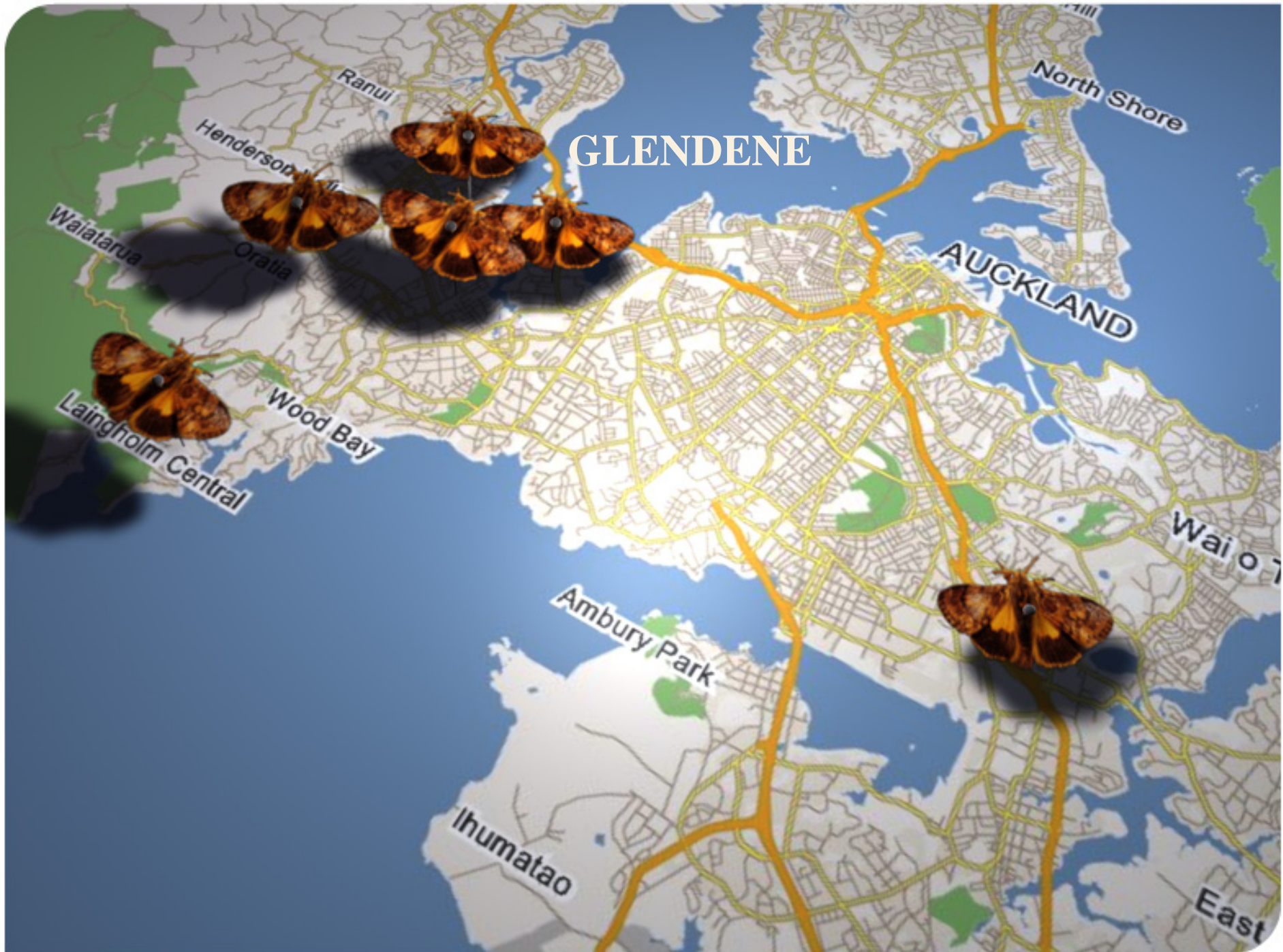
- BIOSECURITY NEW ZEALAND



GLENDENE



GLENDENE



North Shore

AUCKLAND

Wai o

East

Ranui

Henderson Hill

Oratia

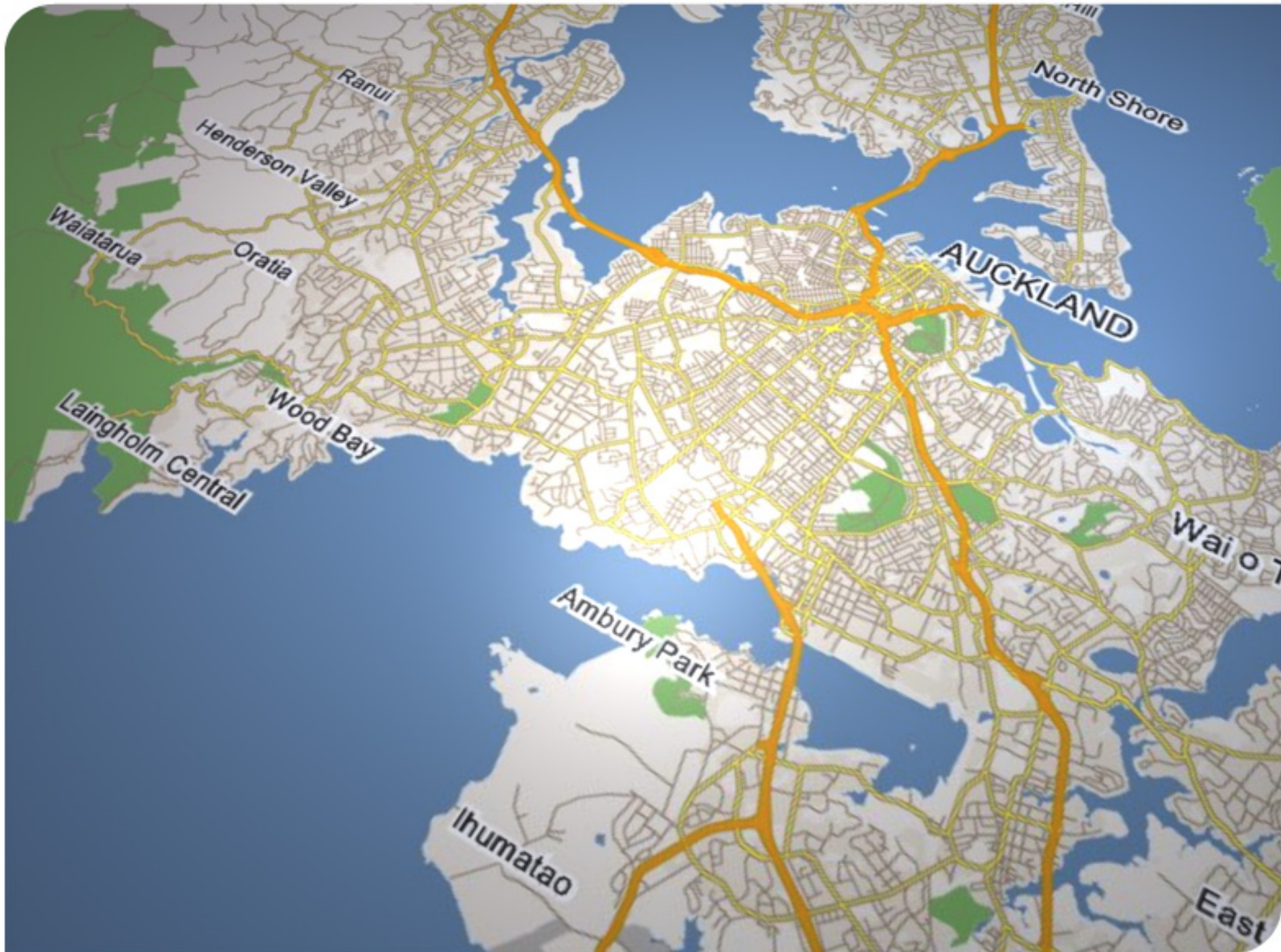
Waiaatarua

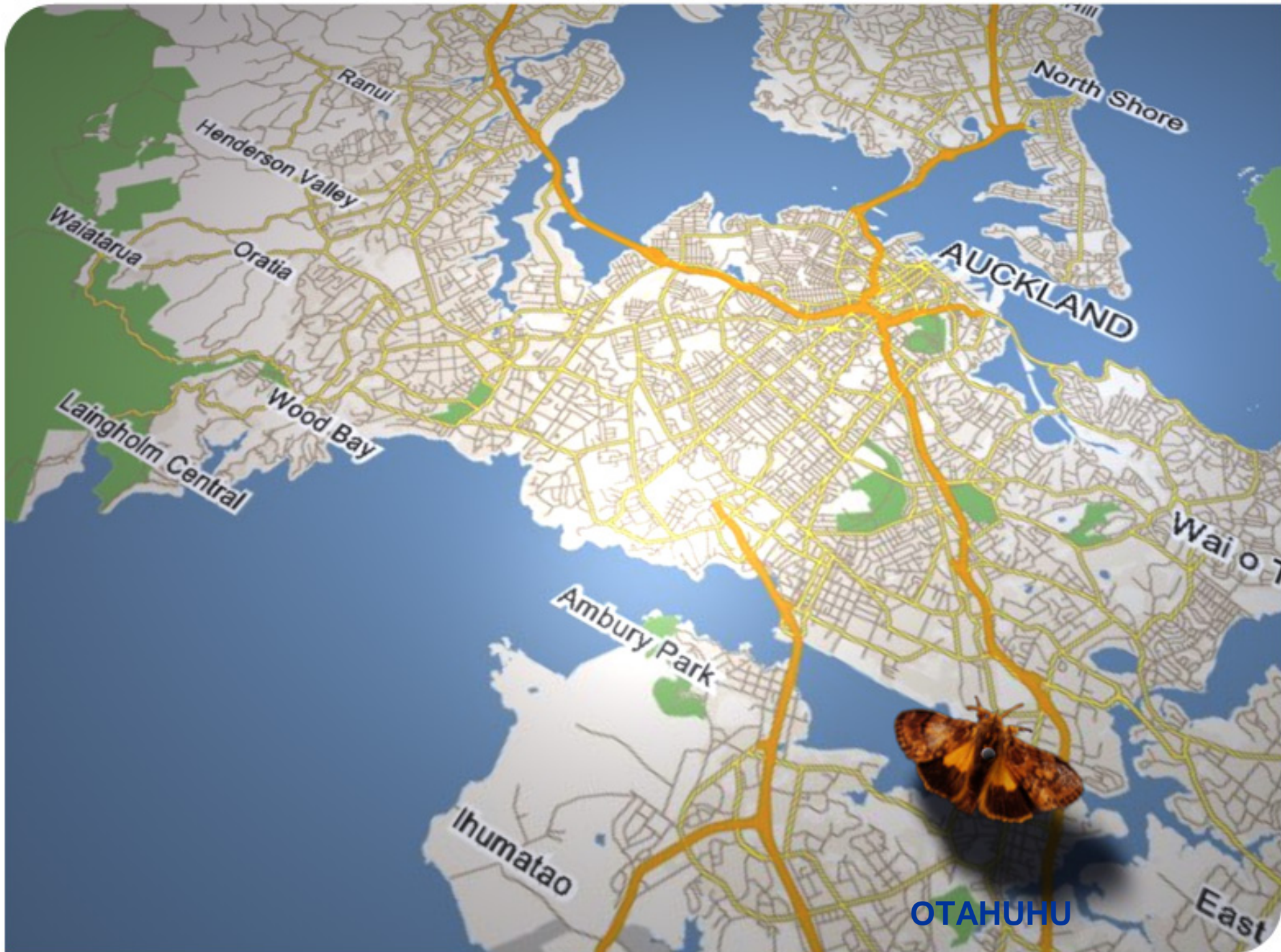
Wood Bay

Laingholm Central

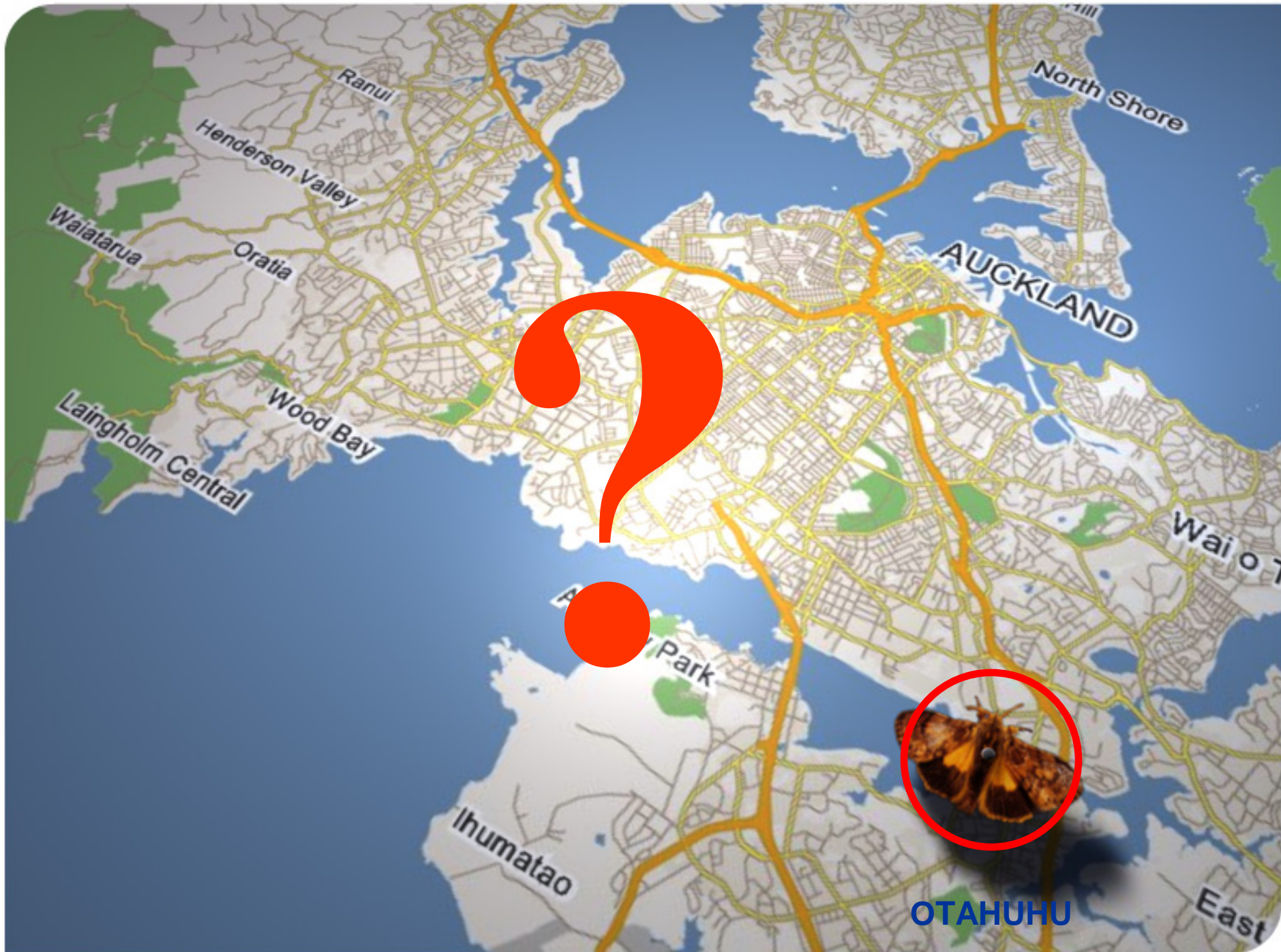
Ambury Park

Ihumatao

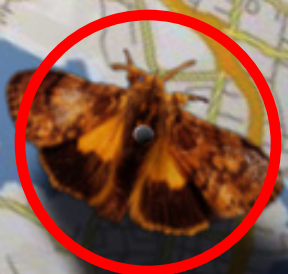




OTAHuhu

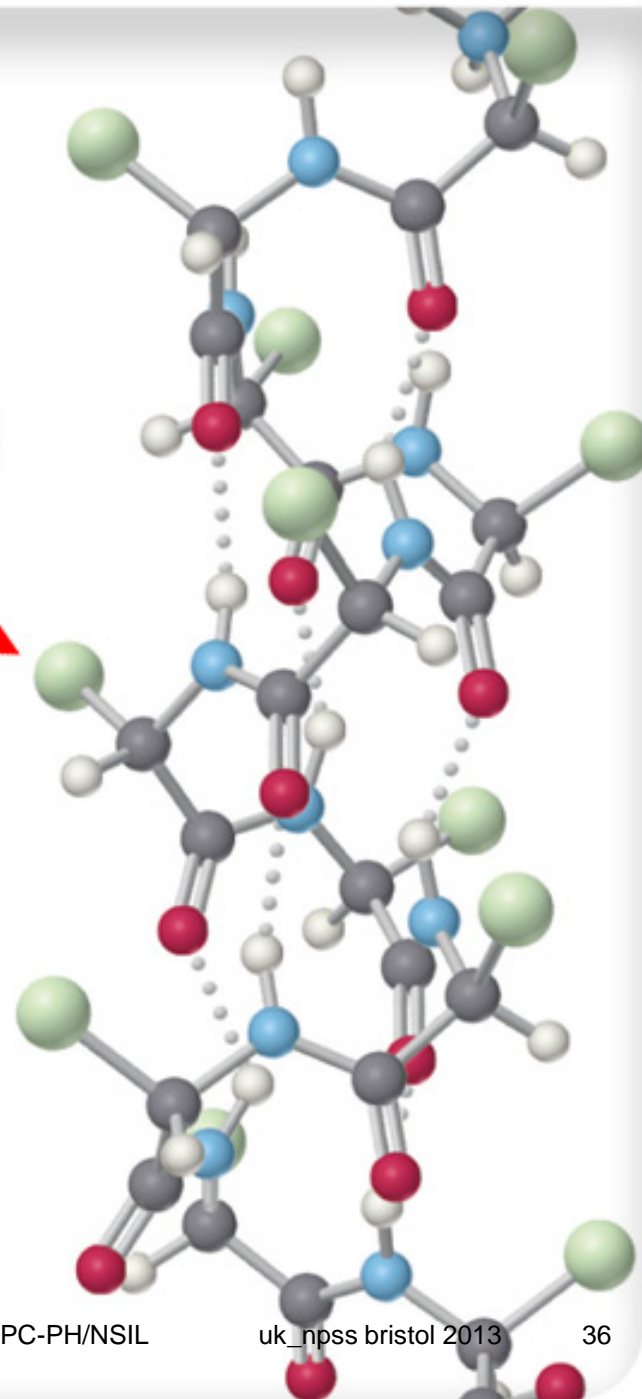
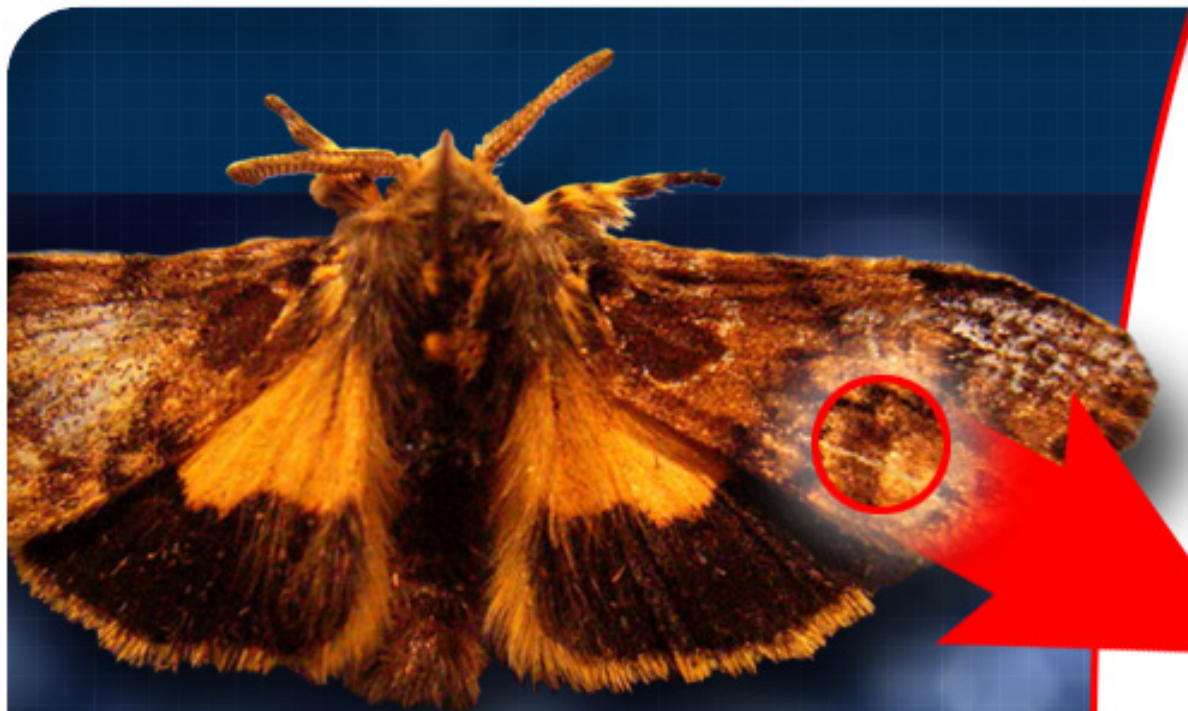


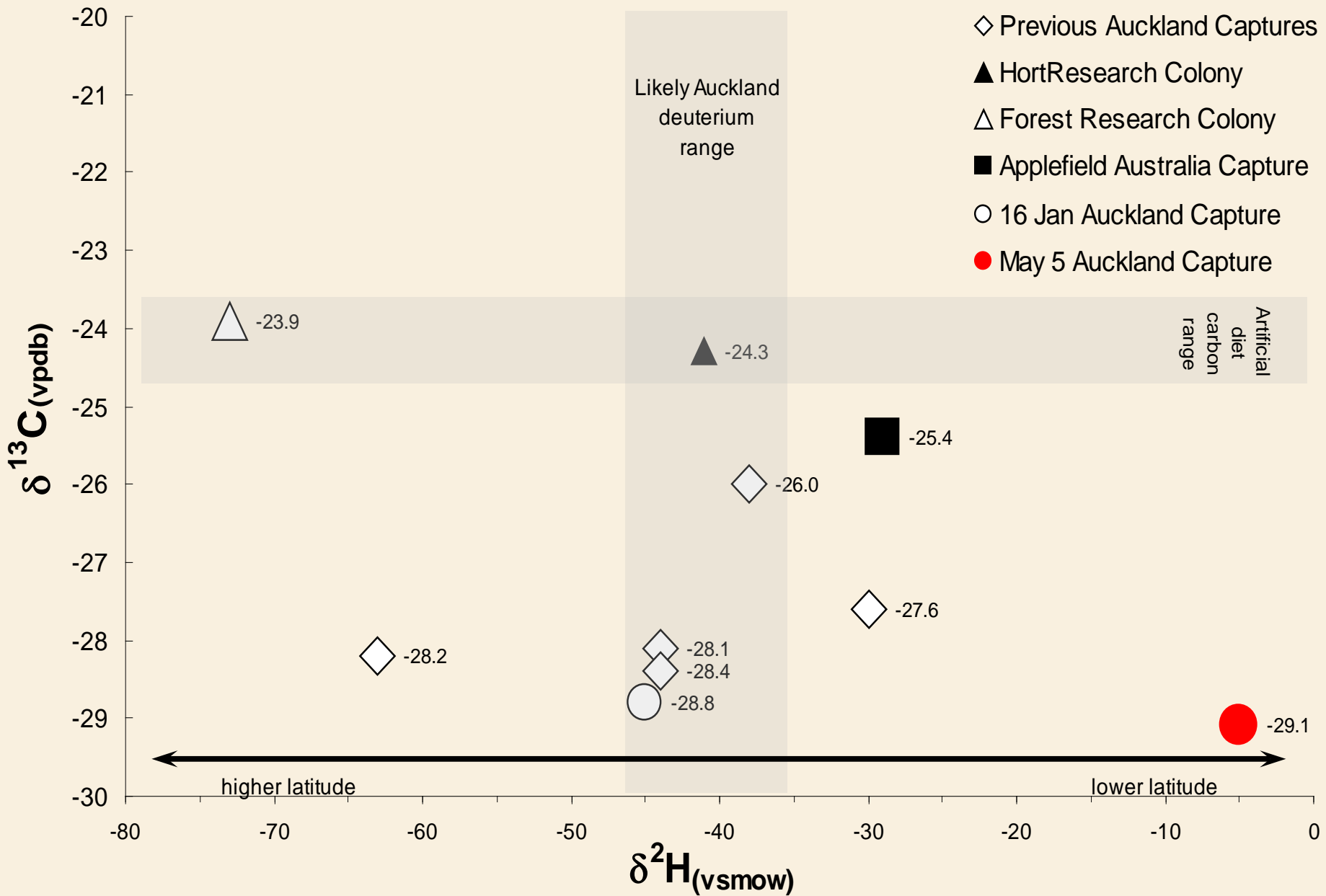
?



OTAHUUU







Not from Auckland



OTAHUHU

PAM Conclusion

- Able to differentiate between moths from different locations
- **Limitations:**
- Assumption that moth skeletal material reflects local precipitation
- Poor resolution of precipitation maps available, especially for NZ

Environment

Responding to the **impacts of environmental changes**

- Establishing **approaches, protocols and standards** for environmental assessments
- Assessing the impacts of **climate change, ocean acidification** and other contaminants on seafood, biodiversity and the marine environment
- Providing reliable environmental
- **radioactivity concentration data**



Tracing the Pollution of the Past

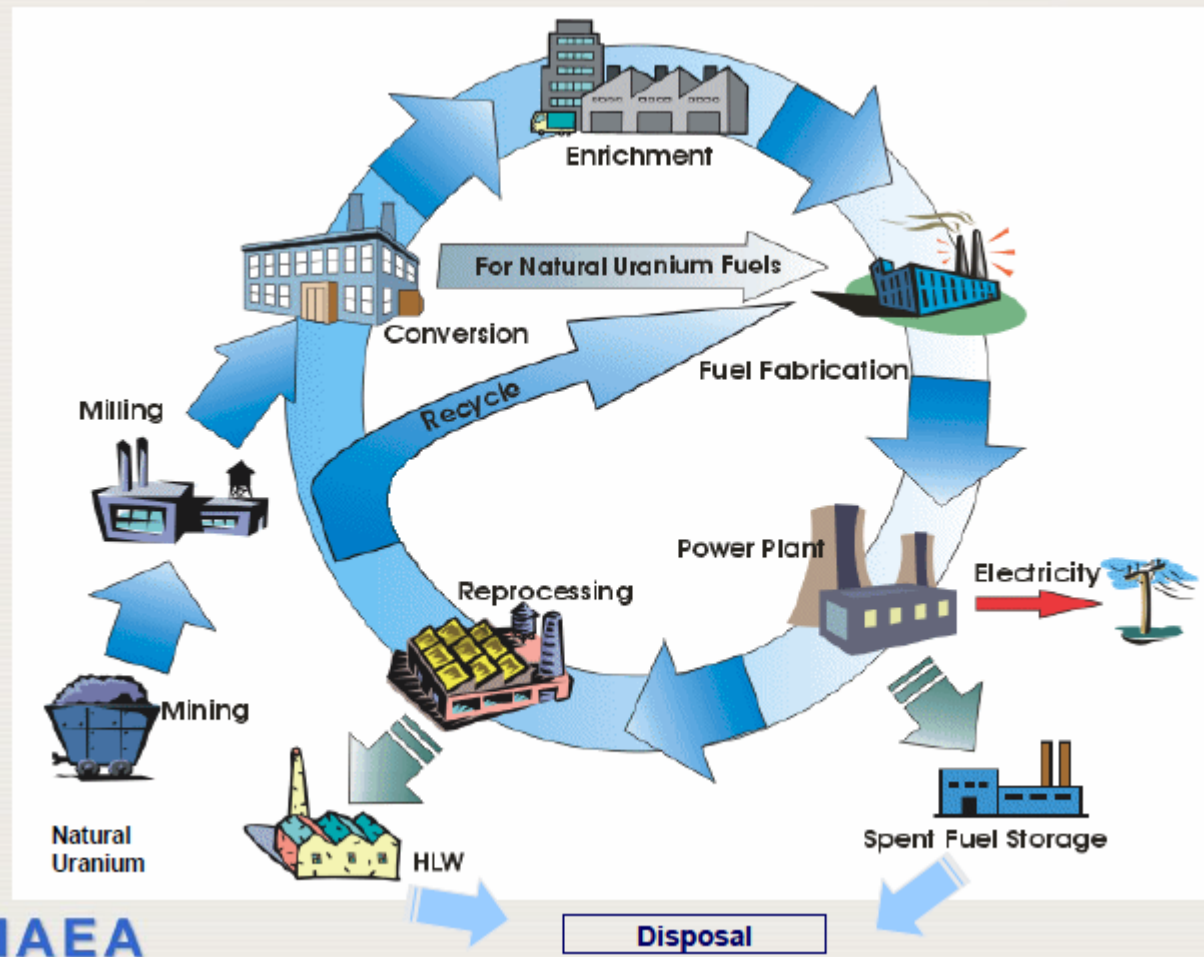
<http://www.youtube.com/watch?v=Q1SKOCETB38>

Uploaded on Sep 19, 2011

The IAEA is helping twelve countries in the Caribbean to understand and manage coastal pollution. Led by the IAEA's experts in aquatic and marine environment, the project has established a network of experts and laboratories across the Caribbean basin. This network of scientists and laboratories are using nuclear techniques to uncover traces and types of pollution that settle in the sea bed.

The Caribbean network now trains further experts in nuclear techniques and provides isotopic analysis capacity. That analytical capacity allows governments to identify and track pollution from the sea back to its source on land, where practices can be changed to prevent further pollution.

Nuclear Fuel Cycle



Uranium exploration and mining



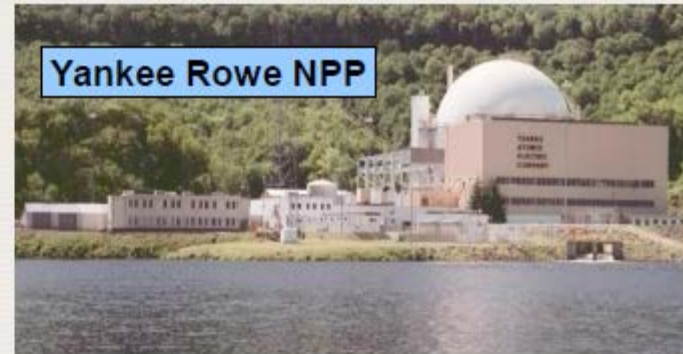
MEGATEM, Dash 7



Decommissioning



Maine Yankee being dismantled, USA



Disposal of low level waste



**Final Covering of the Low Level Waste
Disposal Facility at Centre de la Manche (France)**

“Orphan” radioactive sources



Millions of radioactive sources are safely used around the world...



*however there have
been accidents...*

Radiological accident in Goiania, Brazil



- Abandoned radiotherapy machine taken for scrap:
- Several buildings contaminated

➤ 249 people contaminated

➤ 49 people with 'high doses'

➤ 4 people died: 6y old girl; 18y old man; 22y old man; 38 y old mother

Istanbul (1998/9)



Original source container

- 2 abandoned radiotherapy sources
- 10 persons with acute radiation syndrome
- 404 persons medically examined



Source containers found at scrapyards

Securing Radioactive Sources

http://www.youtube.com/watch?v=ngq_6AzP738

Published on May 17, 2013

A team of experts from South Africa's Nuclear Energy Corporation has removed 16 highly radioactive sources from disused medical devices in the Philippines.

The source removal experts used a special facility known as a "mobile hot cell" to carry out the six-week operation, which was financed by the IAEA's Nuclear Security Fund

End of Part I

Thanks for your attention

Specific acknowledgement to

Russell Frew (FEPL)

Ronald Pacheco (NSRW)

<http://www.youtube.com/user/IAEAvideo>



IAEA

International Atomic Energy Agency