EMB Brown Bag Lunch n° 5

Welcome!

The livestream will start at 13:00 CEST

Prof. Aaron Micalef @MicallefAaron @GEOMAR_en
European Marine Board @EMarineBoard

European MARINE BOARD
Advancing Seas & Ocean Science

OFFSHORE FRESHENED GROUNDWATER:

AN UNCONVENTIONAL WATER RESOURCE IN COASTAL REGIONS?

Aaron Micallef
GEOMAR Helmholtz Centre for Ocean Research, Kiel, Germany
Department of Geosciences, University of Malta, Malta

Christian Berndt (GEOMAR), **Ariel T. Thomas** (University of Malta)

L-Università ta' Malta

GEOMAR

Offshore freshened groundwater (OFG)

water with a salinity below that of seawater, stored in pores of sediments and fractures of rocks in the sub-seafloor

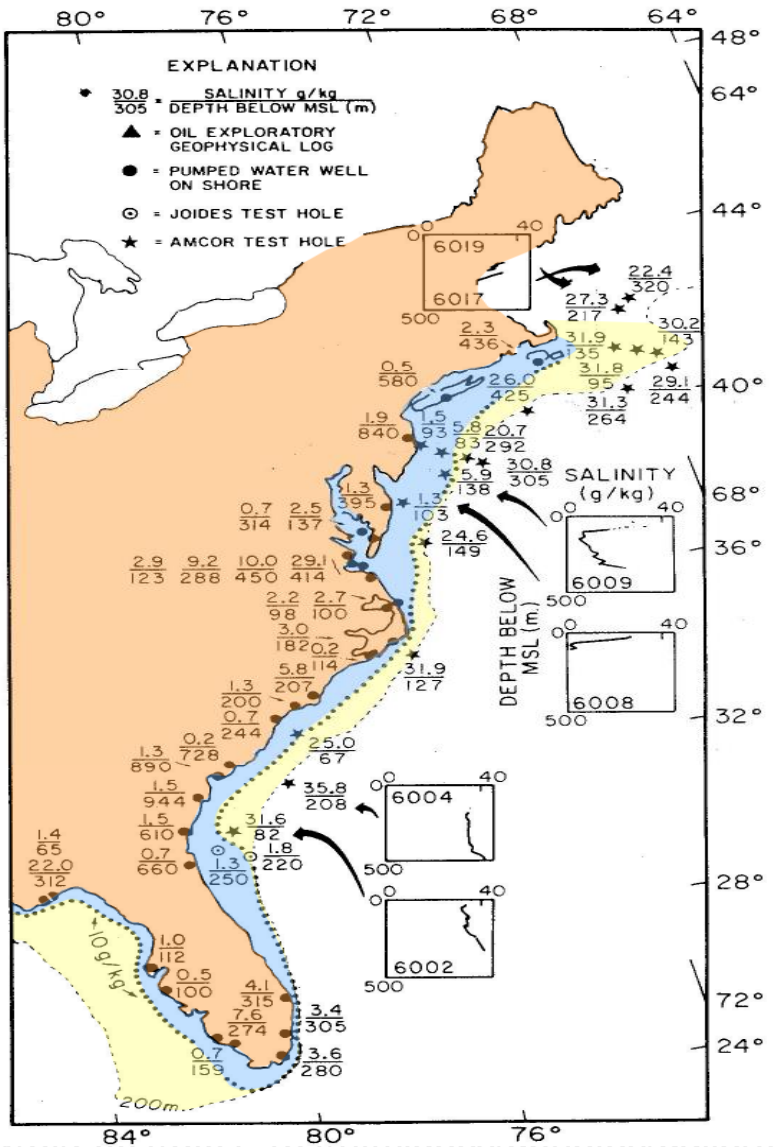
1. WHAT IS OFG?

2. HOW DO WE STUDY OFG?

3. WHY IS OFG IMPORTANT?

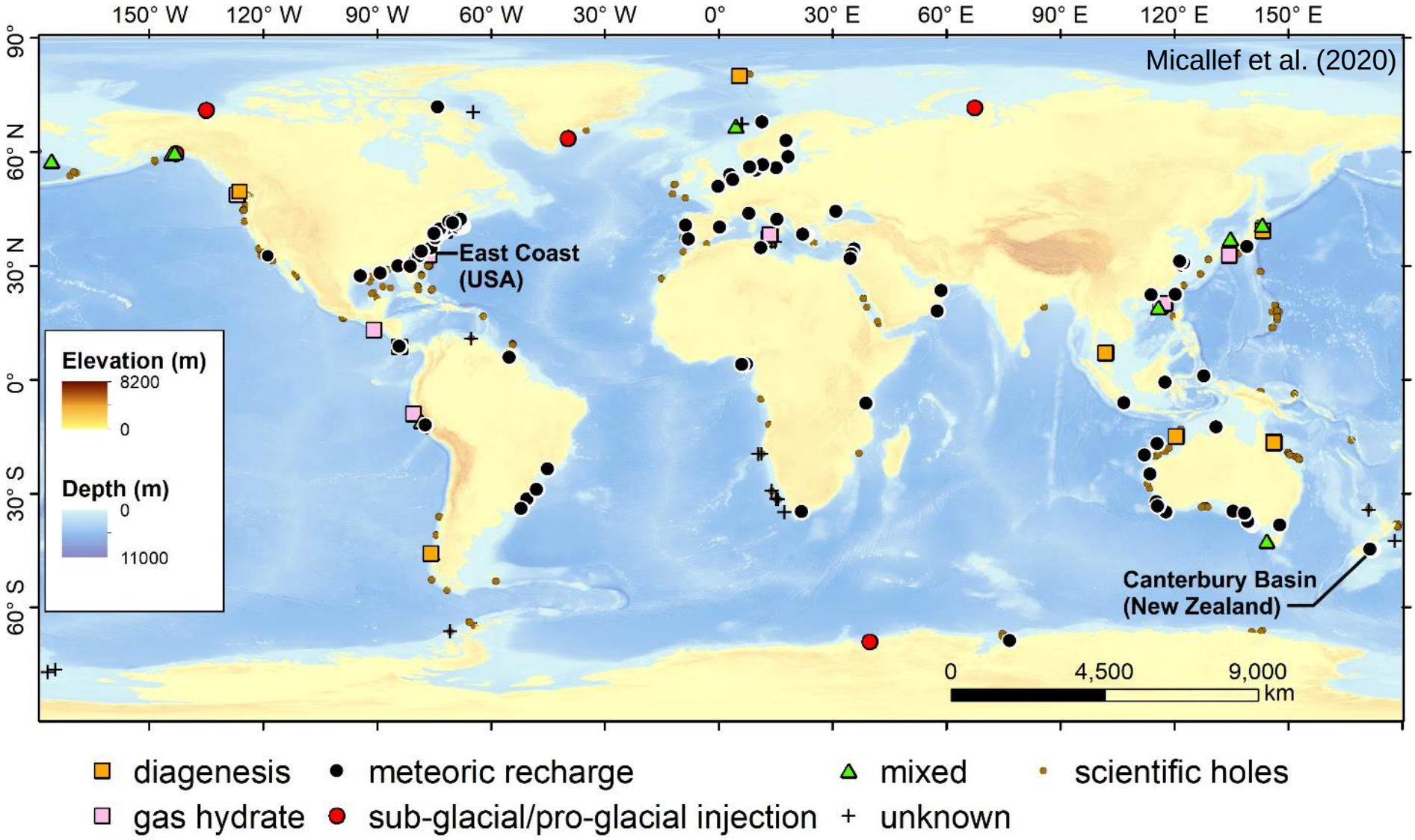
4. IS OFG UTILISATION FEASIBLE?

1 WHAT IS OFG?



Hathaway et al. (1979)

1.1 Global database



1.2 Emplacement mechanisms

ⓐ

Active, present day recharge

(d) Diagenesis

ⓑ

Recharge during sea-level lowstands

(e) Gas hydrate decomposition

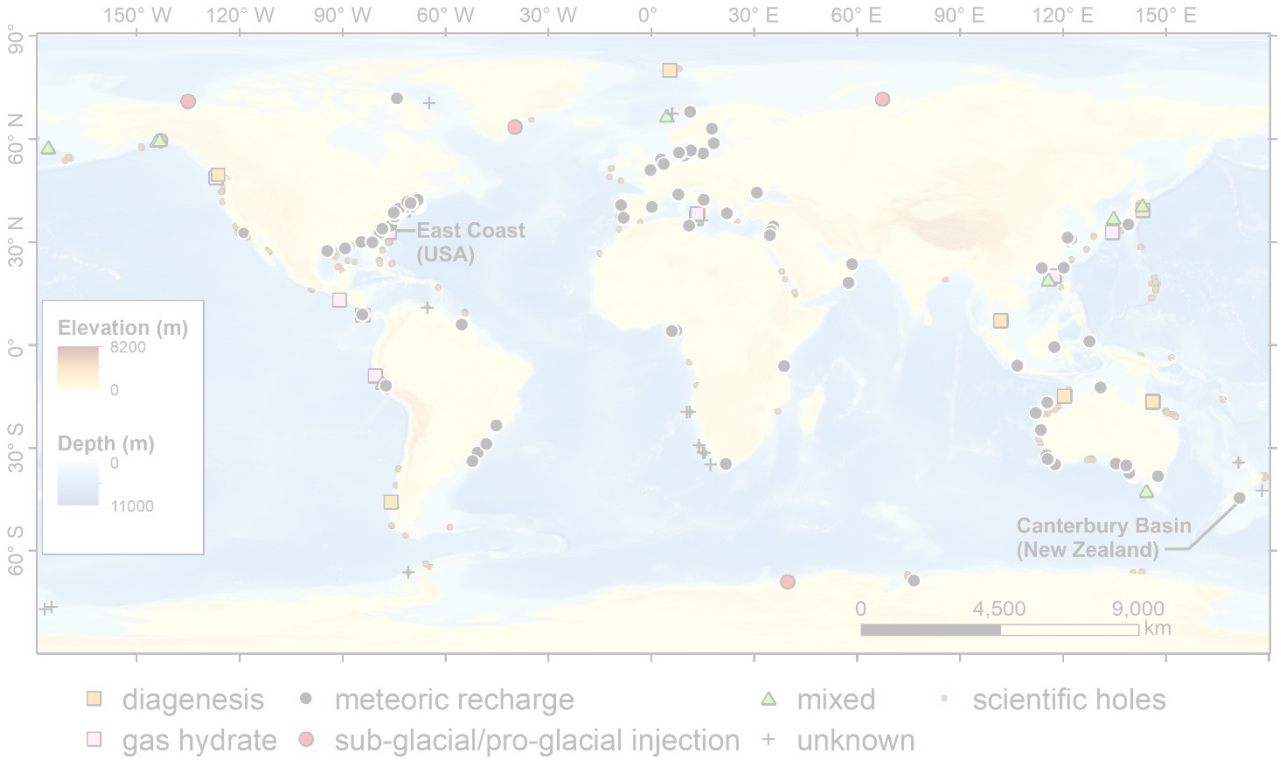
ⓒ

Sub-glacial and pro-glacial injections

1.3 Spatial characteristics

- Within **50 km** of the coast
- Down to water depth of **100 m**
- Top of OFG at **0-200 m** below seafloor
- Multiple OFG bodies that are **<1 km** thick
- **Siliciclastic** aquifers
- Mean salinity of **15 PSU**

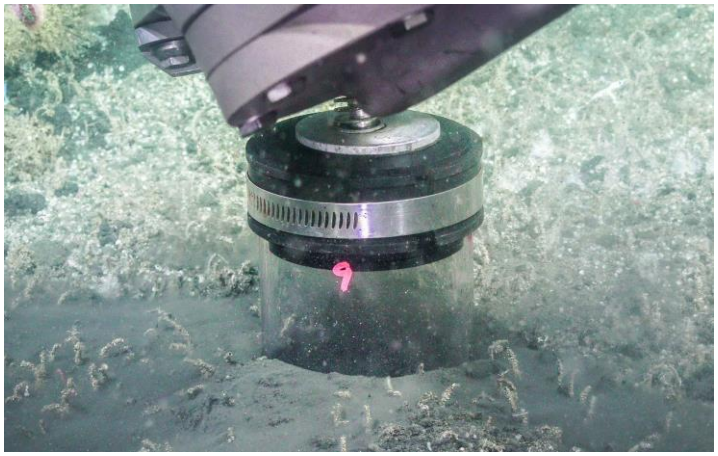
1.4 Global volume



1 million km^3

2 HOW DO WE STUDY OFG?

2.1 Drilling, coring, logging

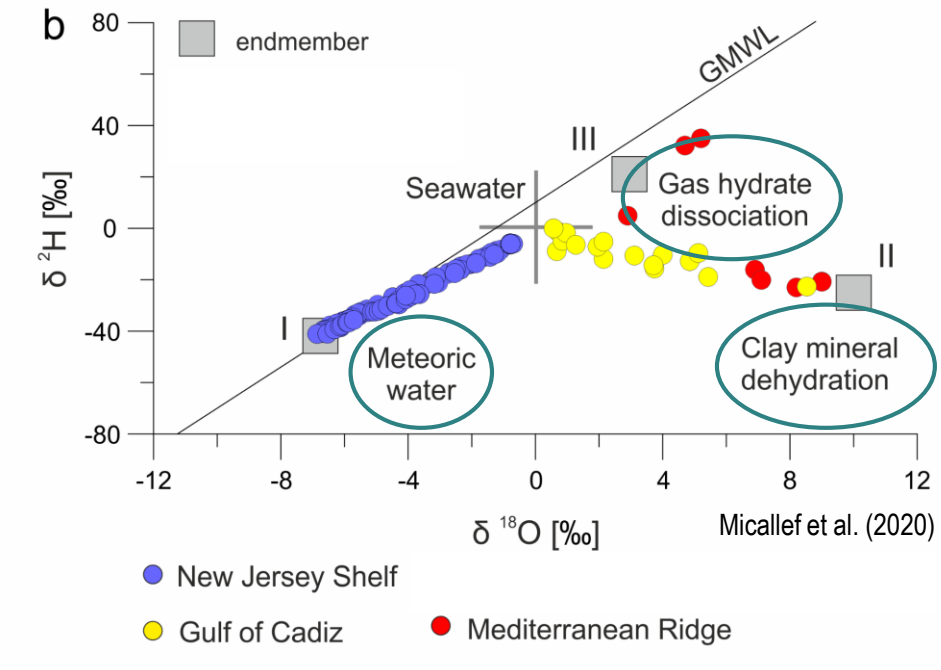


www.usgs.gov

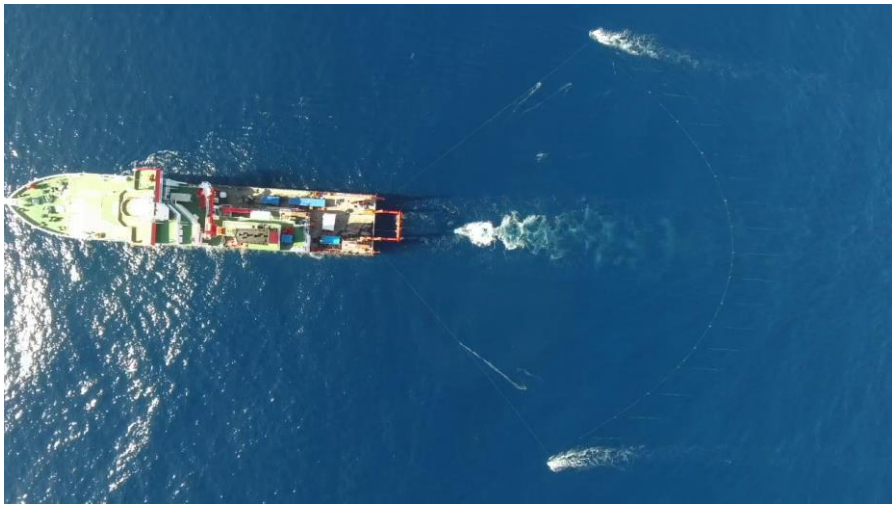
www.iodp.org

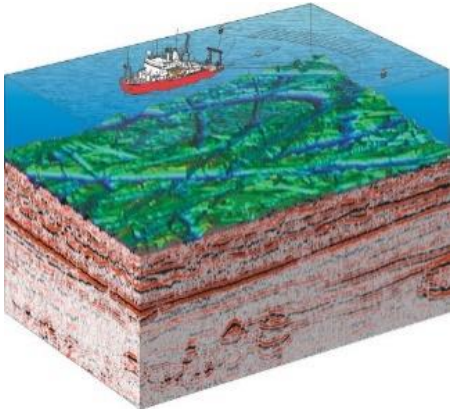
2.2 Geochemical methods

- Chlorinity, total dissolved solids
- Stable isotopes ($\delta^{18}O$; $\delta^{2}H$)



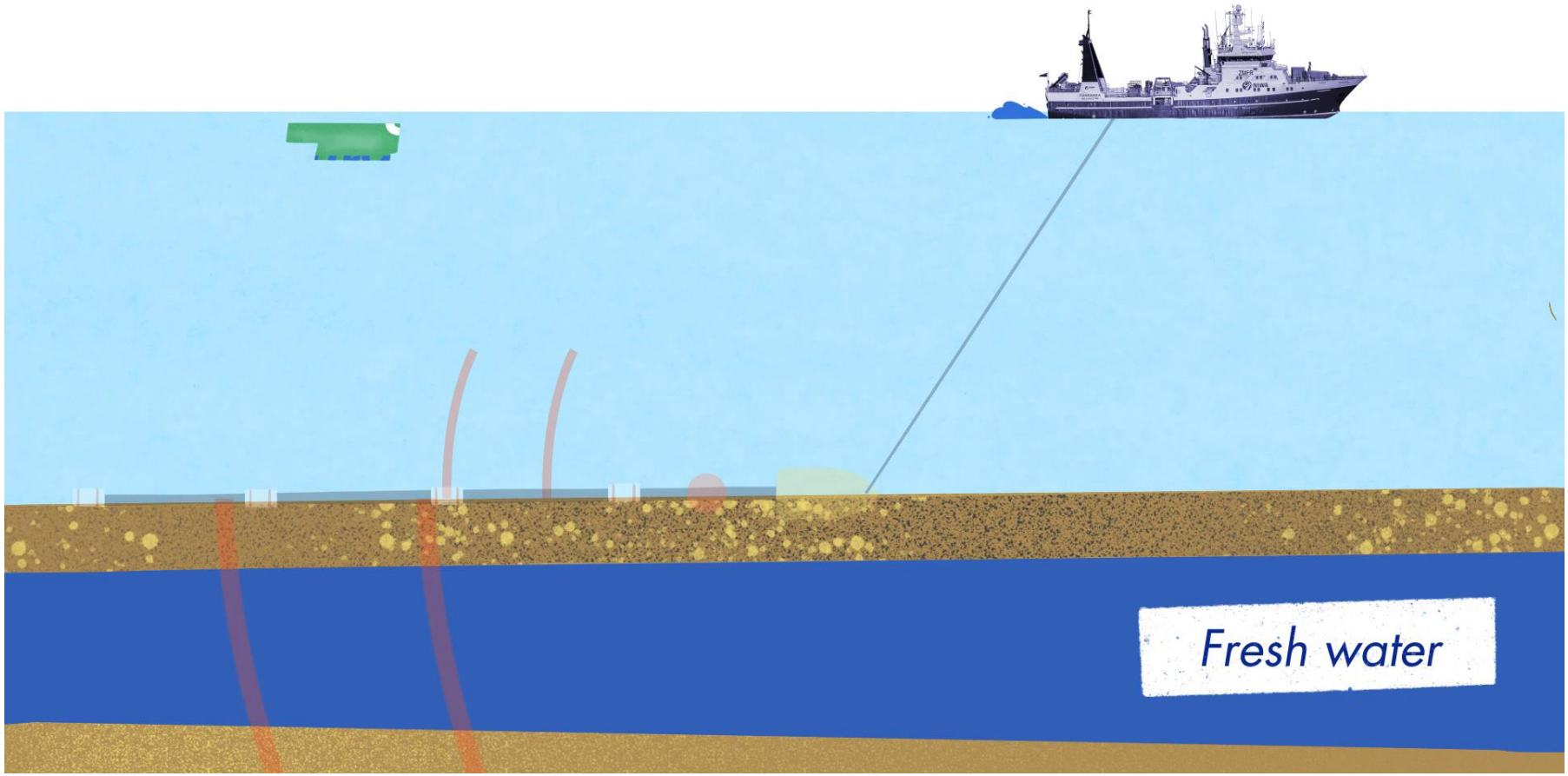
2.3 Geophysics – reflection seismics



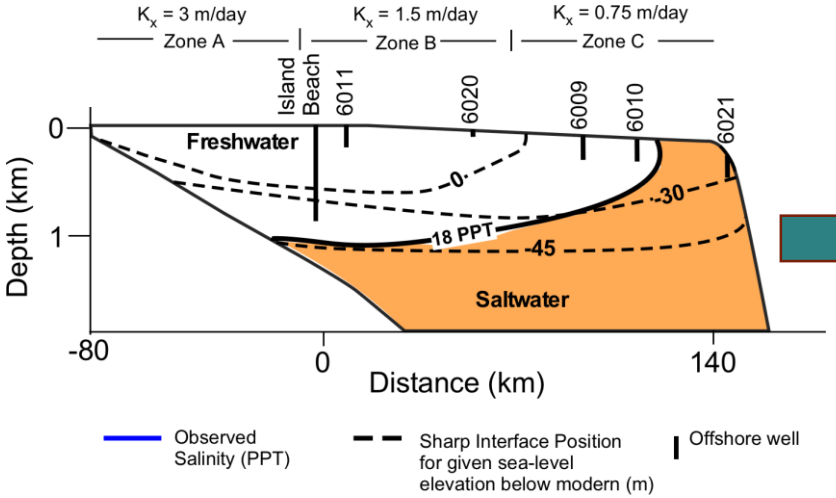


- Lithology
- Geometry
- Permeability
- Connectivity
- Focused fluid flow structures
- Buried channels
- Faults
- Depositional environment

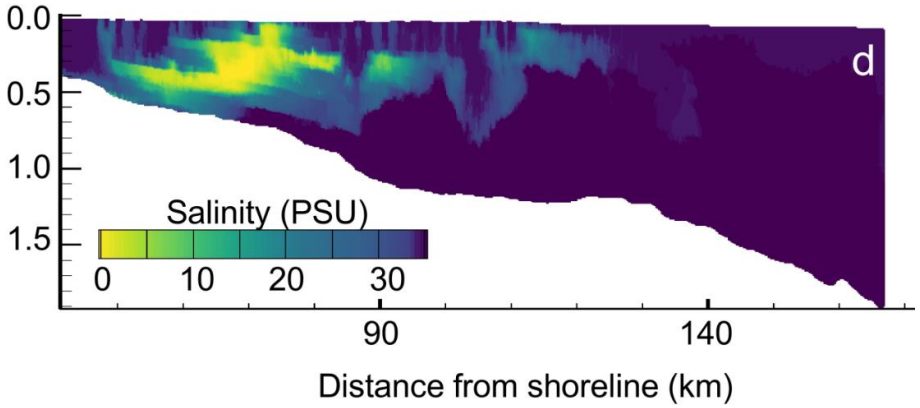
2.3 Geophysics – electromagnetic surveying



2.4 Numerical modelling

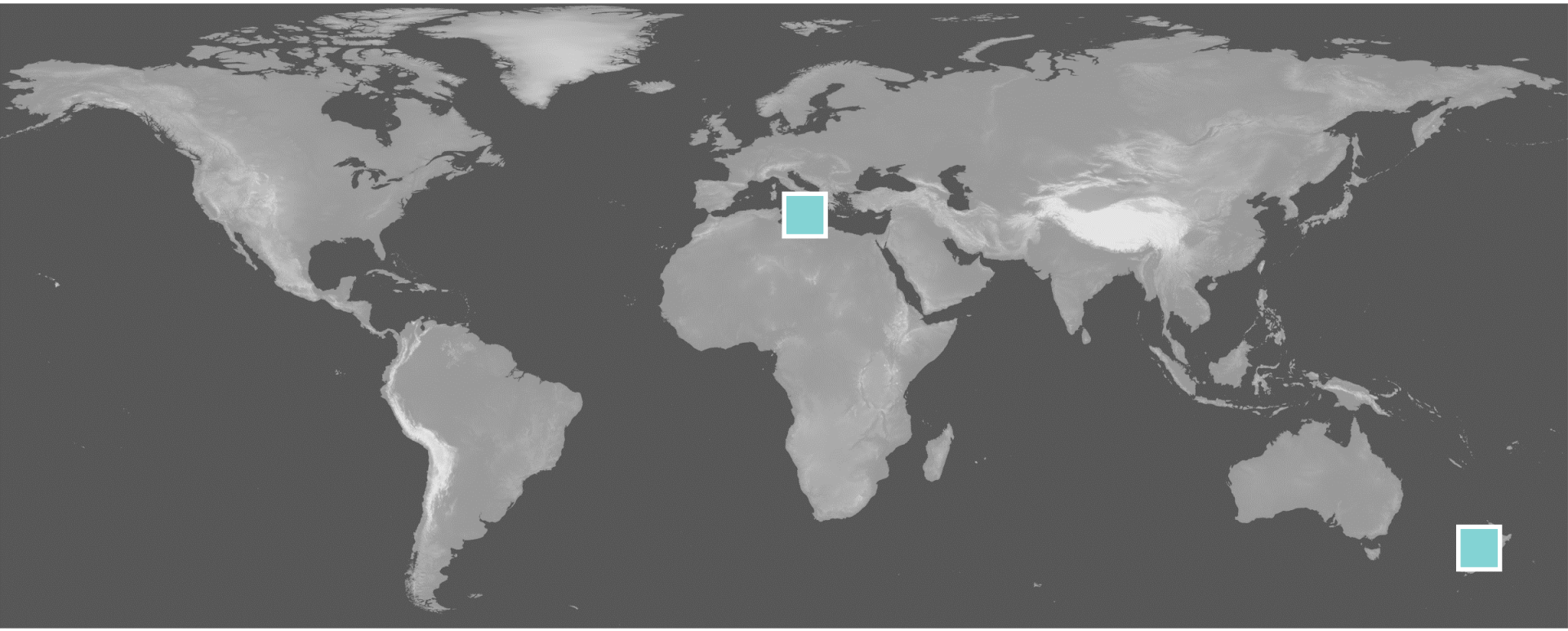


Meisler et al. (1984)

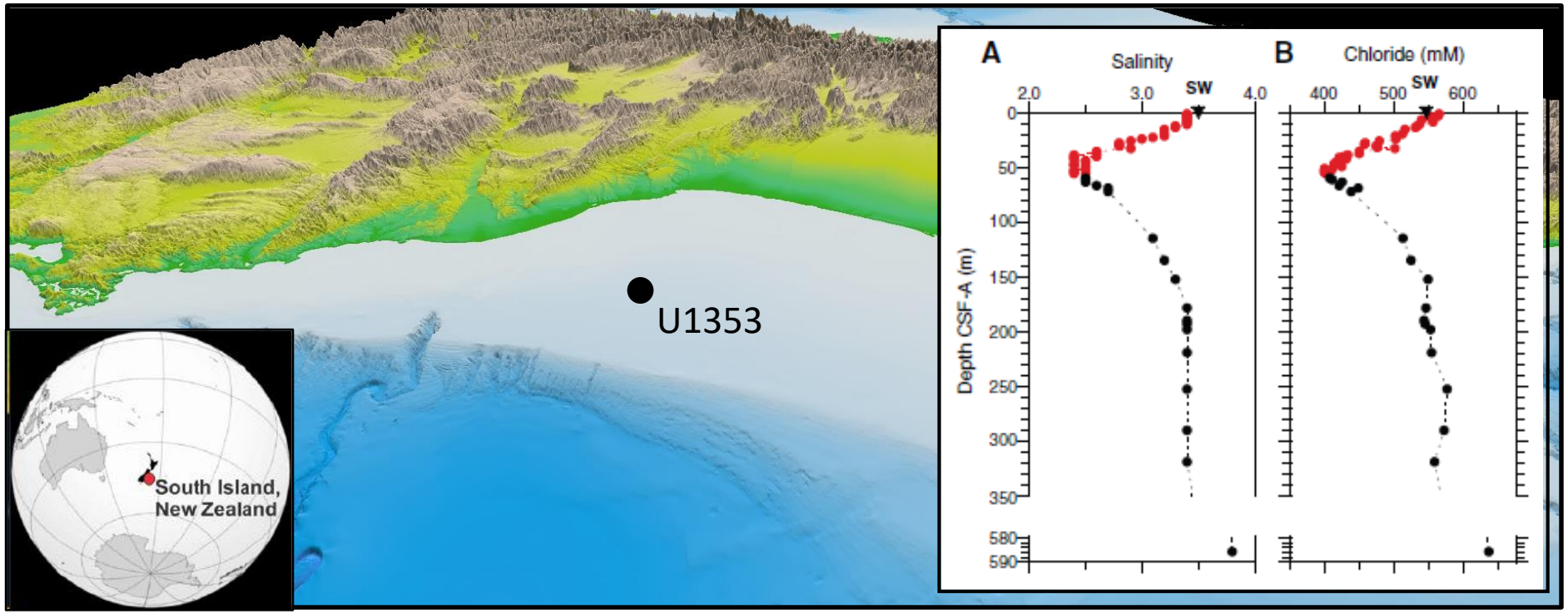


Thomas et al. (2019)

2.5 Case studies

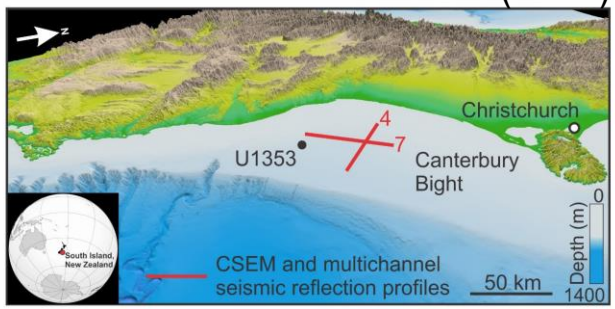


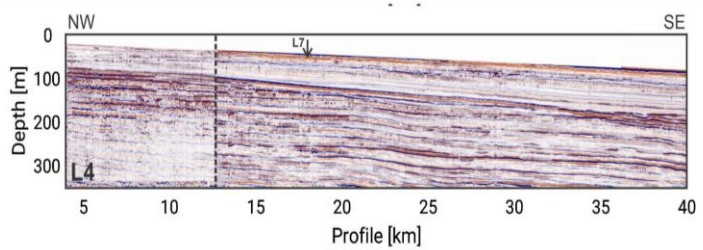
2.5 Case study: Canterbury Bight (New Zealand)

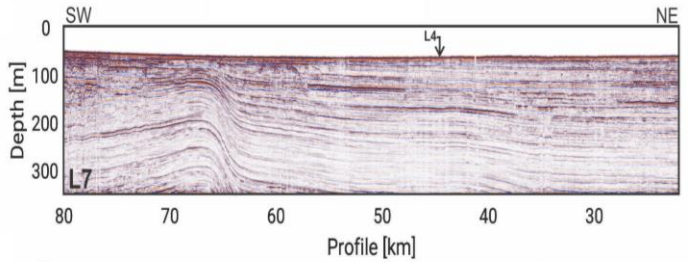


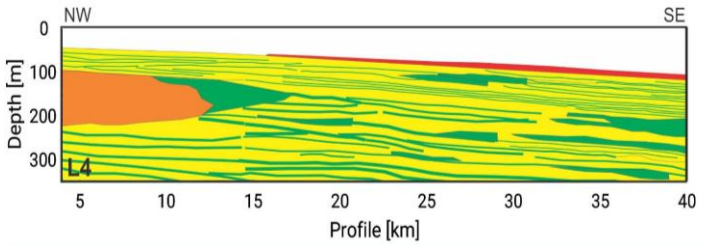
2.5 Case study: Canterbury Bight (New Zealand)

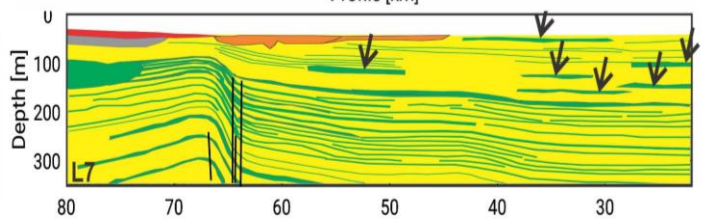
Micallef et al. (2020)

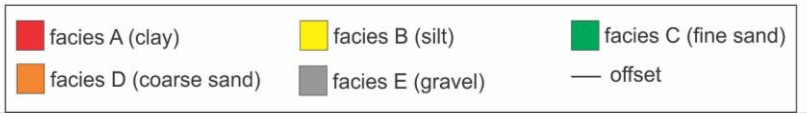


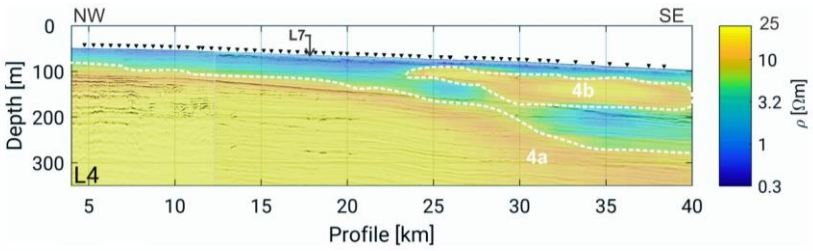


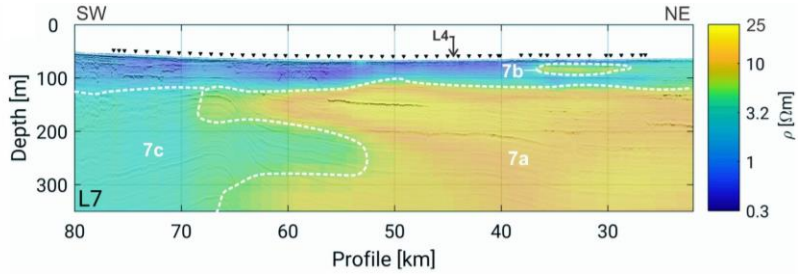




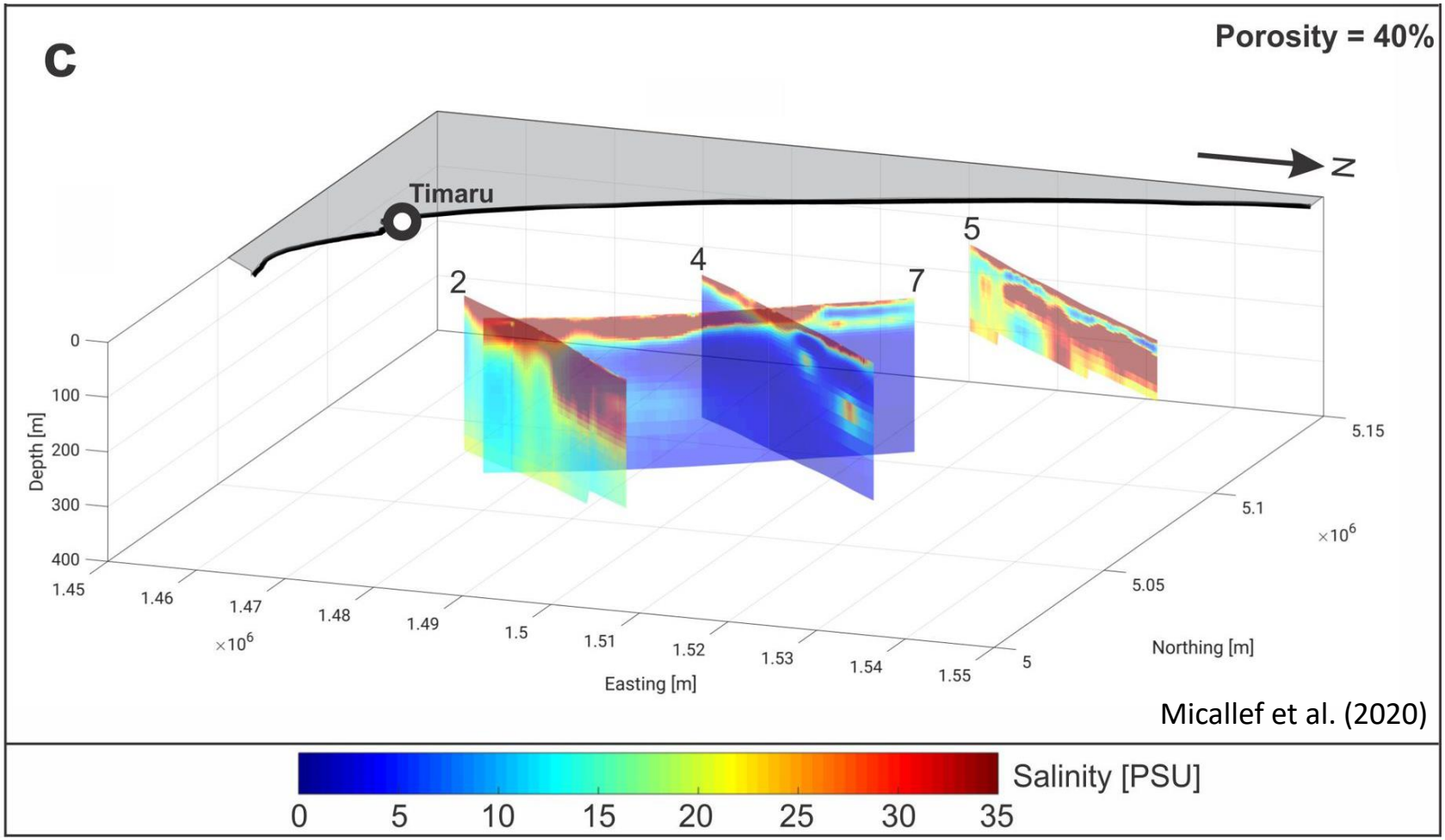






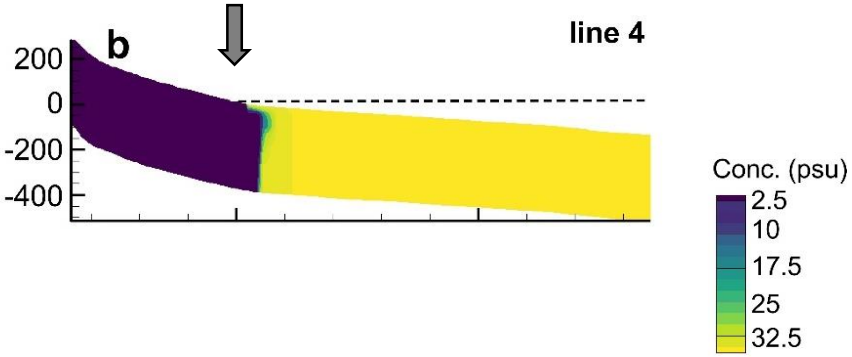


2.5 Case study: Canterbury Bight (New Zealand)

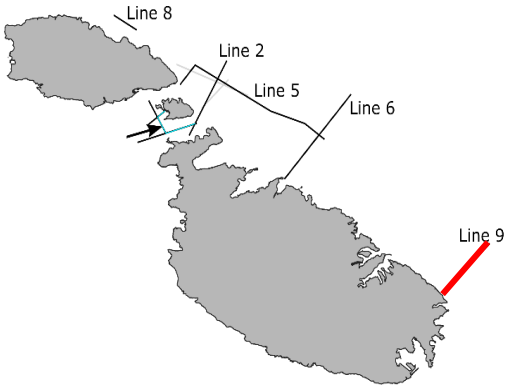


Volume of freshwater (<10 PSU): 200 km^3

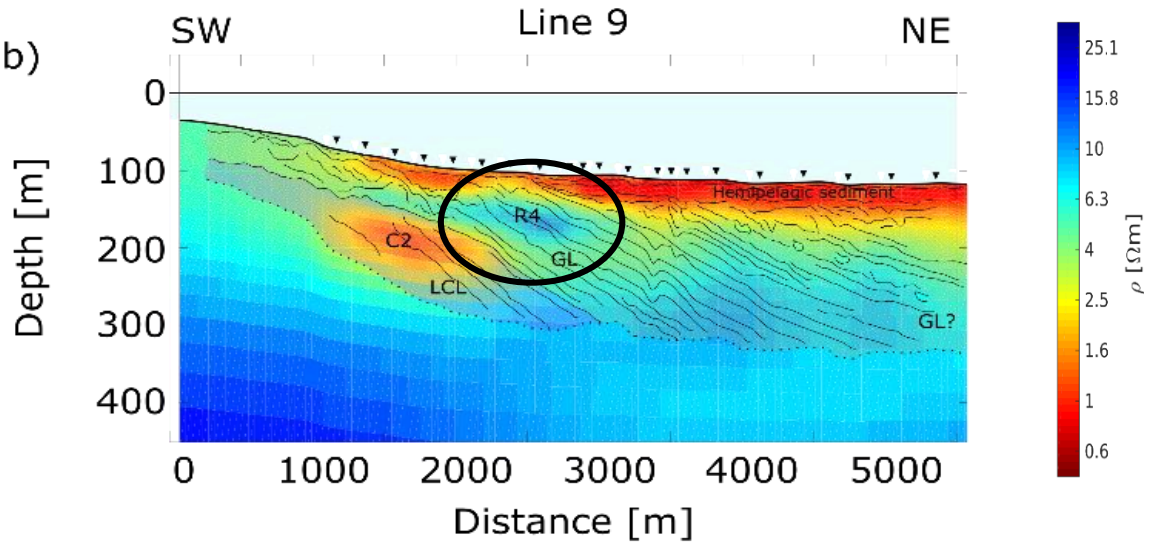
2.5 Case study: Canterbury Bight (New Zealand)



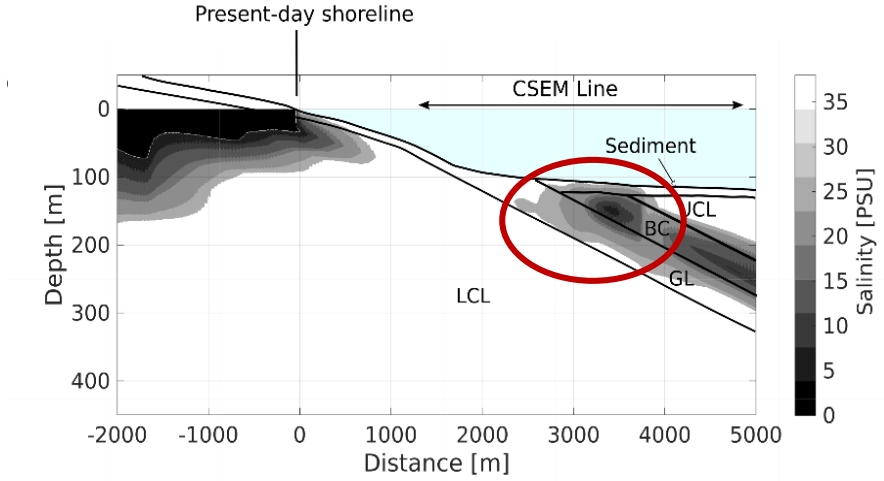
2.5 Case study: Maltese Islands



2.5 Case study: Maltese Islands



Haroon et al. (2021)



2.6 Current projects in Europe

MARCAN

erc

SMART
A Helmholtz European Partnering Initiative

M6MTOFGR

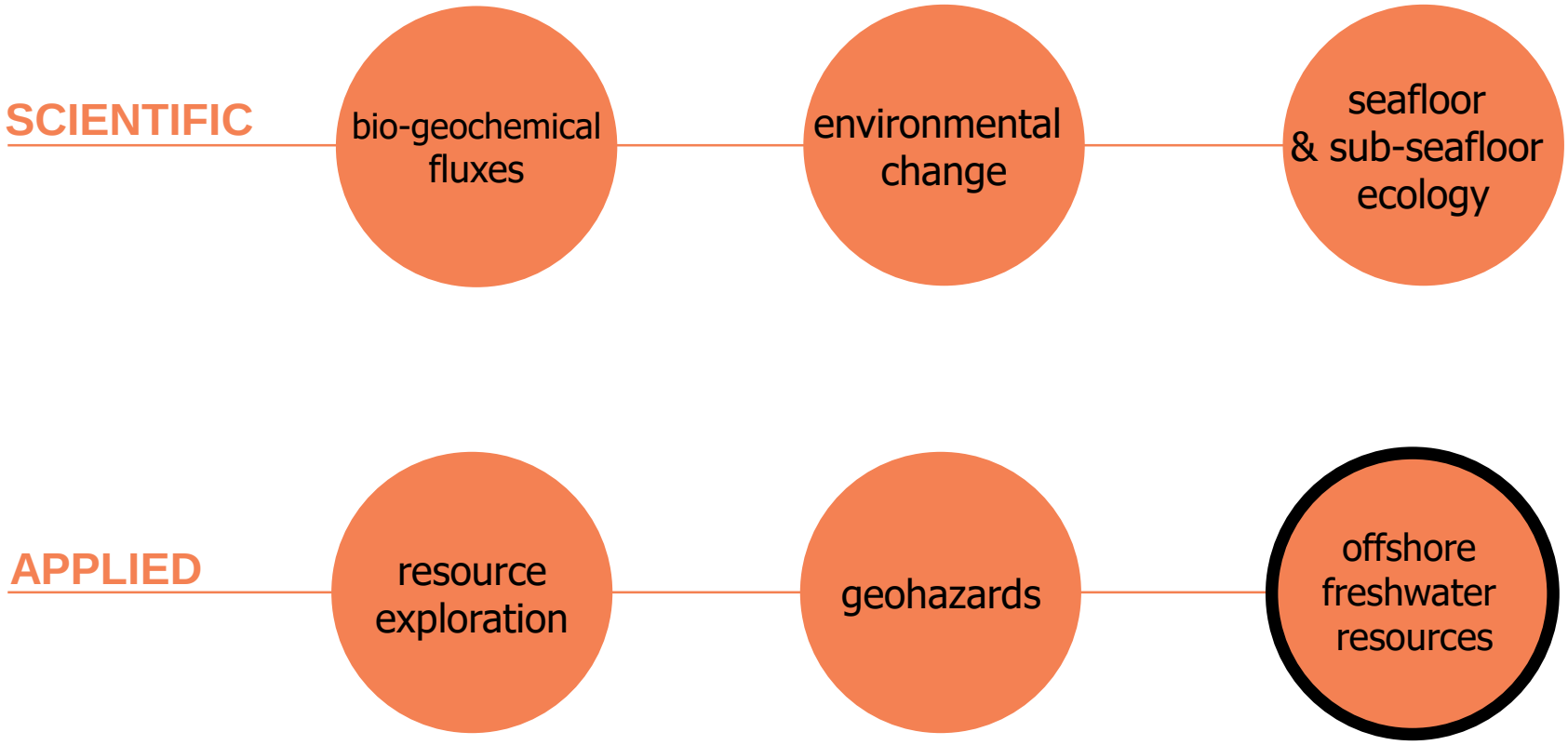
swan

Marie Skłodowska-Curie Actions

OFF-GROUND
KARST

3 WHY IS OFG IMPORTANT?

Significance of OFG



3.1 Offshore freshwater resource

Water Resour Manage (2012) 26:1015–1026
DOI 10.1007/s11269-011-9806-1

BBC | Sign in | News | Sport | Weather | Shop | Earth | Travel

NEWS

Home | Video | World | Asia | UK | Business | Tech | Science | Stories | Entertainment

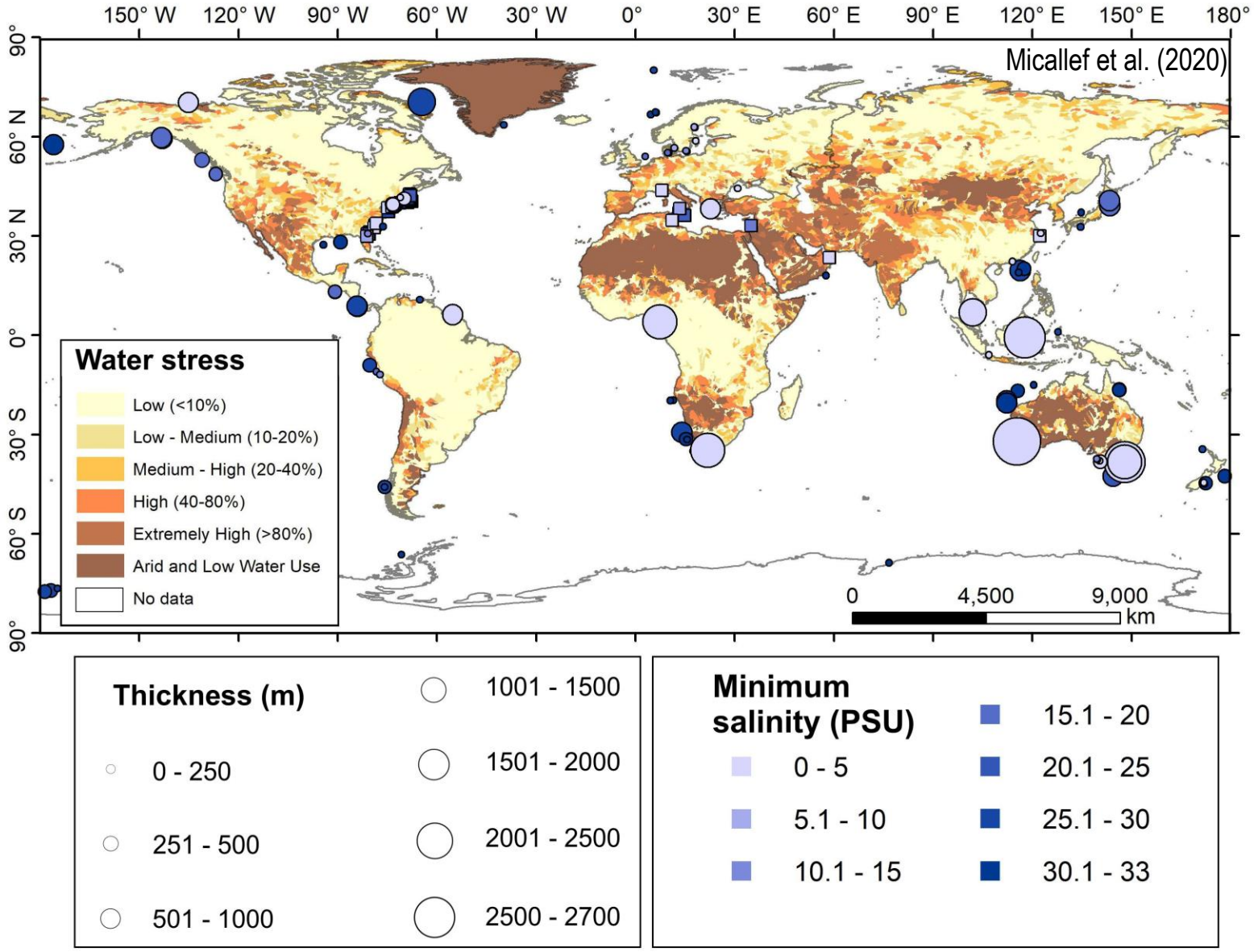
World | Africa | Australia | Europe | Latin America | Middle East | US & Canada

The 11 cities most likely to run out of drinking water - like Cape Town

11 February 2018 | Share

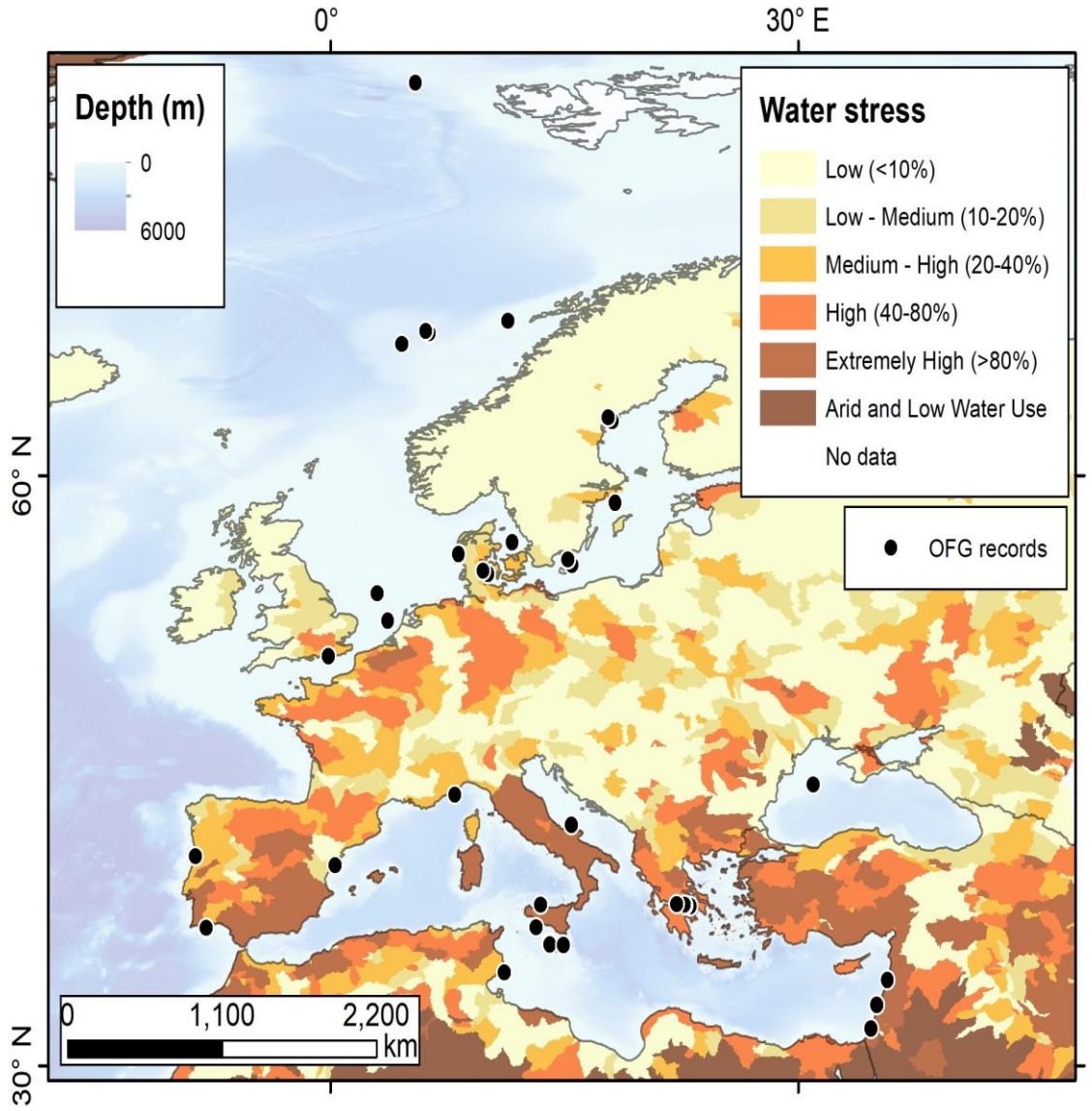
e.g. Cape Town, Chennai, São Paulo, Shanghai

3.1 Offshore freshwater resource

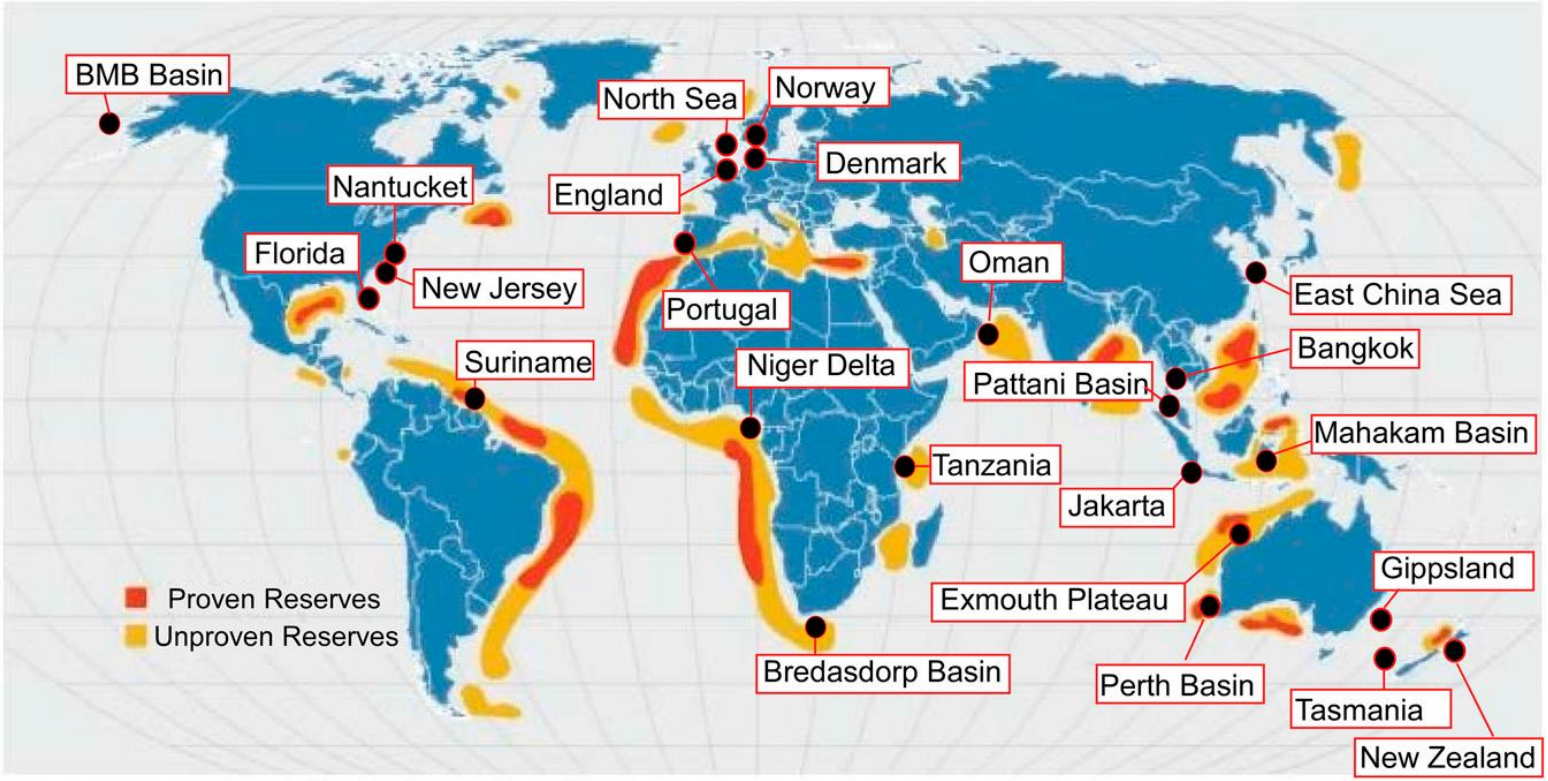


3.1 Offshore freshwater resource

OFG site	Offshore distance (km)	Thickness (m)
Baltic Sea	70	23
Beaufort McKenzie Basin	100	1000
Bredasdorp Basin (South Africa)	100	2000
Canterbury Bight (New Zealand)	60	250
Gippsland (Australia)	10	1600
Hong Kong	2	40
Israel	3.5	150
Mahakam Basin	20	2130
Nantucket (USA)	60	500
Niger Delta	40	1840
Perth Basin (Australia)	50	2700
Suriname	90	600


0°
30° E
60° N
30° N
Depth (m)
0
6000
Water stress
Low (<10%)
Low - Medium (10-20%)
Medium - High (20-40%)
High (40-80%)
Extremely High (>80%)
Arid and Low Water Use
No data
OFG records
0
1,100
2,200
km

3.2 Offshore freshwater resource



Person et al. (2017)

4 IS OFG UTILISATION FEASIBLE?

a Appropriate data and approaches

b Technological and economic feasibility

c Environmental impacts

d Legal framework

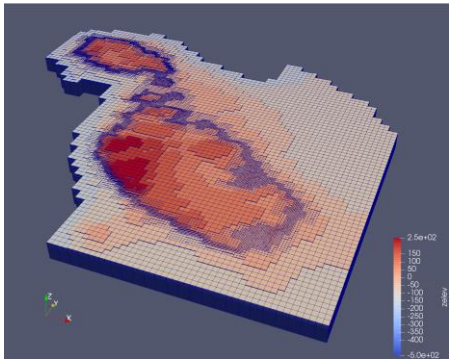
4.1 Appropriate data and approaches

1. **Distribution, extent and dimensions** of OFG bodies

2. **Mechanism and timing** of OFG emplacement

3. **Function** of the OFG system

4.1 Appropriate data and approaches



1. Advance **instruments design and data processing/analyses approaches** for OFG mapping and characterisation

2. Develop a **standardised workflow** and encourage its uptake

3. **Apply** workflow extensively

4. Complement with **numerical modelling** at the margin-scale to determine occurrence, extent and function of OFG systems

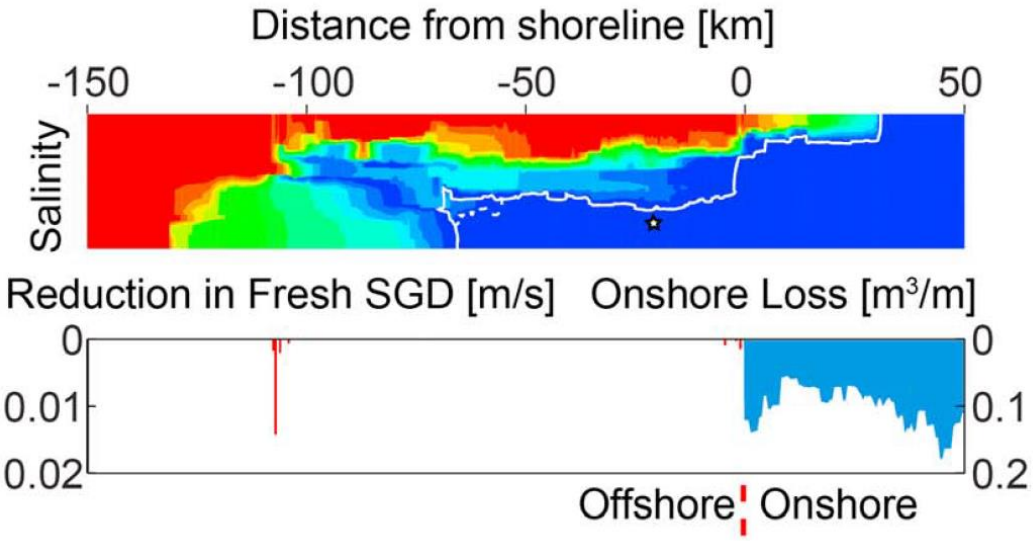
4.1 Appropriate data and approaches

4.2 Technological and economic feasibility

Design a cost-effective **technological framework** for the extraction, transport and treatment of OFG

4.3 Environmental impacts

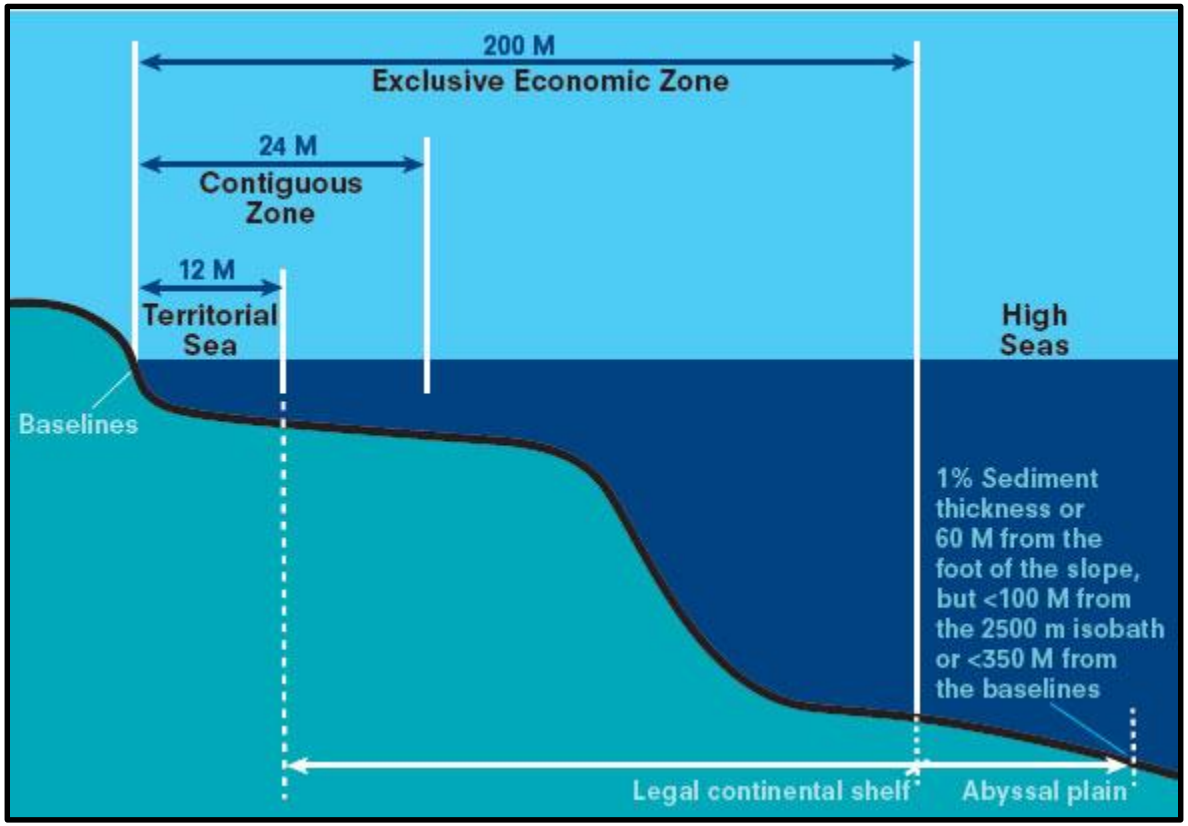
- **Loss of OFG**
- **Surface subsidence**
- Contamination
- Brine disposal
- Habitat degradation
- Cultural noise
- Refuse
- Cross-contamination



Yu and Michael (2019)

Assess and quantify the **impact of pumping and climate change** on OFG resources based on numerical models, field monitoring, and stakeholder participation

4.4 Legal framework



http://www.reparationlaw.com/

Develop **policies, action plans, protocols and legislation** at the local to international levels to guide the exploration and utilisation of OFG resources.

4.5 General

International effort that:

1. Establishes a network of **experts and stakeholders**
2. Fosters **communication** and long-lasting **collaboration**
3. Overcomes communications barrier with **water companies**
4. Trains a **new generation of scientists**

cost
EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY

CA21112 Offshore freshened groundwater: An unconventional water resource in coastal regions? (OFF-SOURCE)

CONCLUSIONS

1. OFG may be a **potential unconventional source of potable water**.

2. Before OFG can be utilised sustainably, there is the need to:

a. Improve our **understanding** of OFG systems
b. Design a **cost-effective technological framework**
c. Assess the **impact of pumping**
d. Develop **legal framework**

3. EU has a unique opportunity to become the **global scientific and technological leader in this field**.

ACKNOWLEDGMENTS

E-mail: **amicallef@geomar.de**