Electromagnetic fields (EMF) and the ocean energy sector

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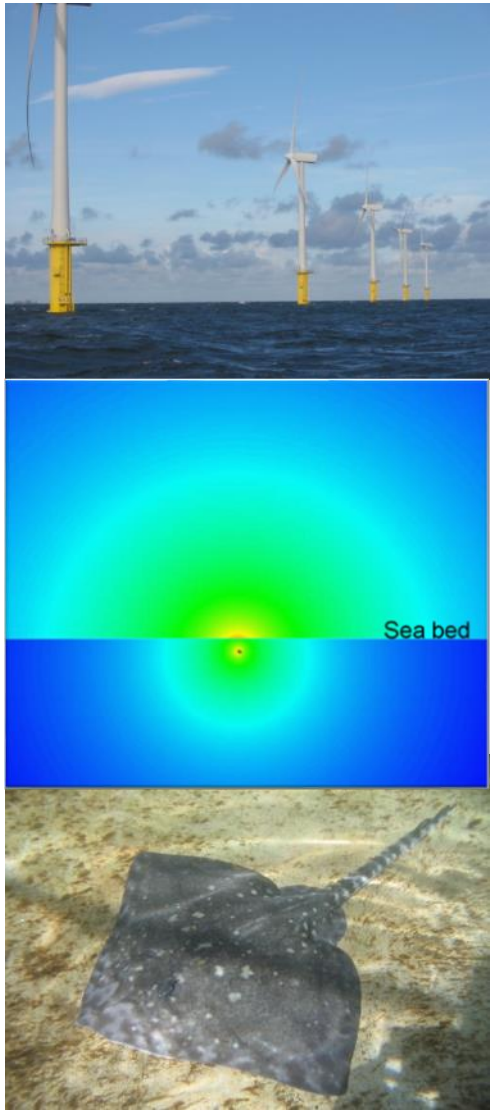
Cefas

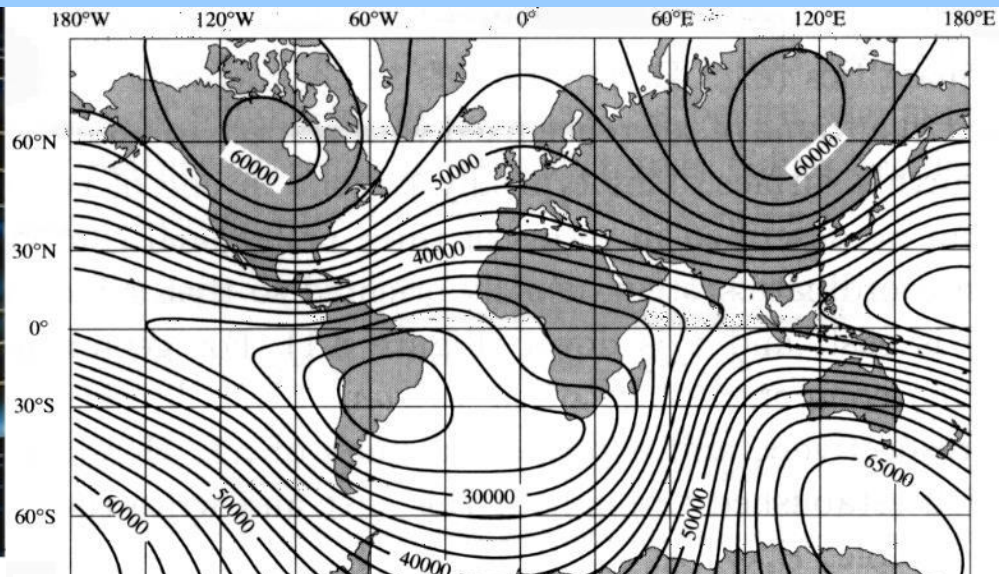
Principal Scientist

PANGALIA Environmental

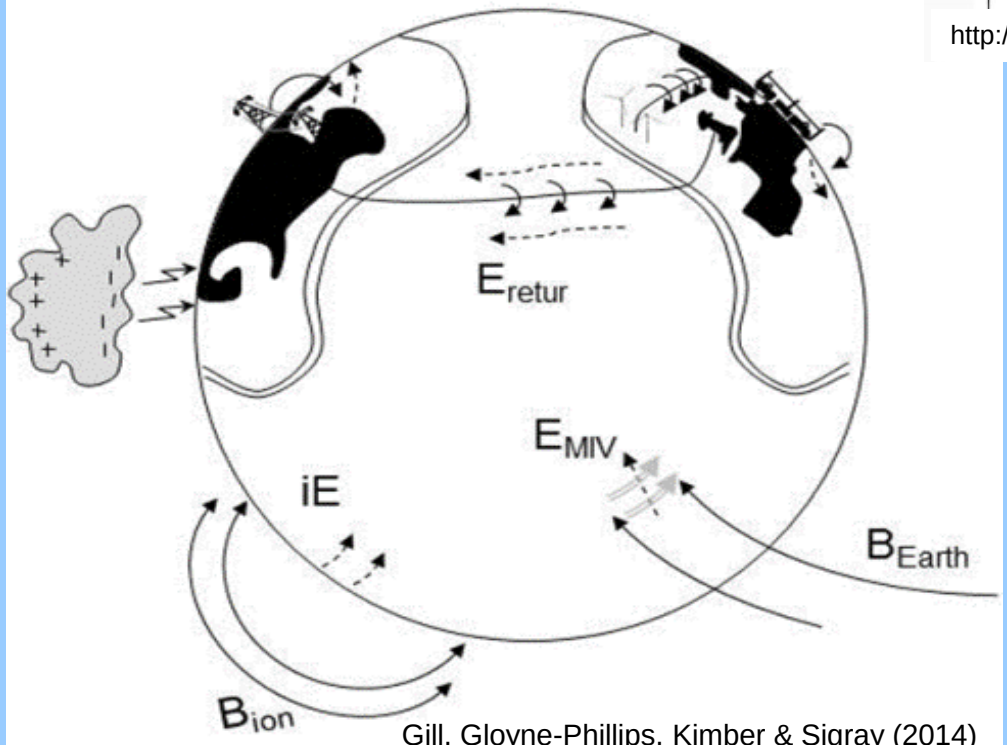
Founder/Owner



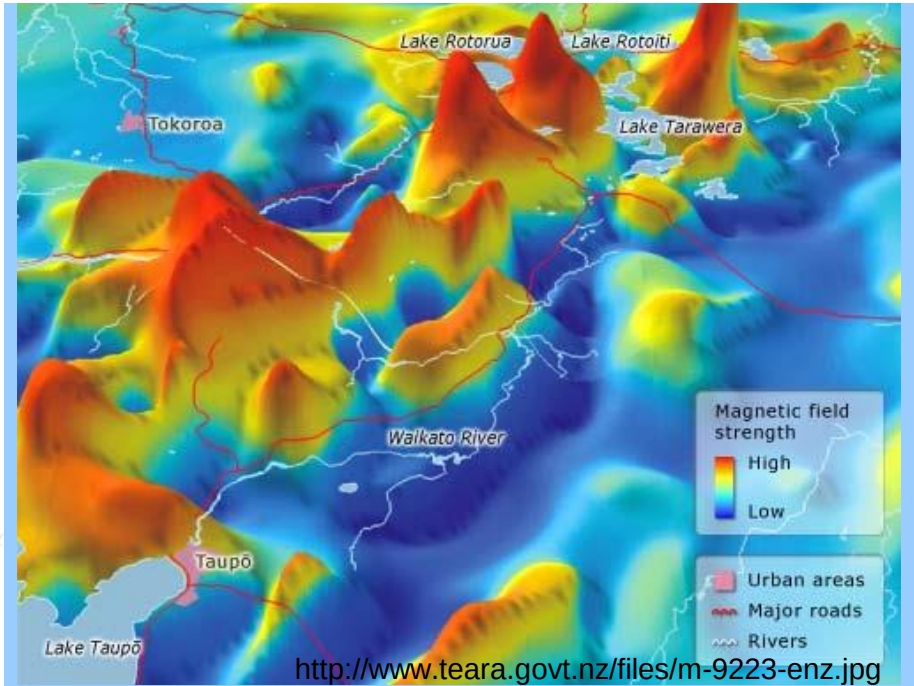
What we know about EMF



http://geophysics.ou.edu/solid_earth/notes/mag_earth/magnetic_field_a.gif



Gill, Glovne-Phillips, Kimber & Sigray (2014)



http://www.teara.govt.nz/files/m-9223-enz.jpg

What we know about EMF – biotic?


http://www.asknature.org/images/


http://left-out.net/photo/content/2015/5/blue-whale

E-M sensitive animals have evolved (and continue) to live in an EMF environment (both AC and DC)

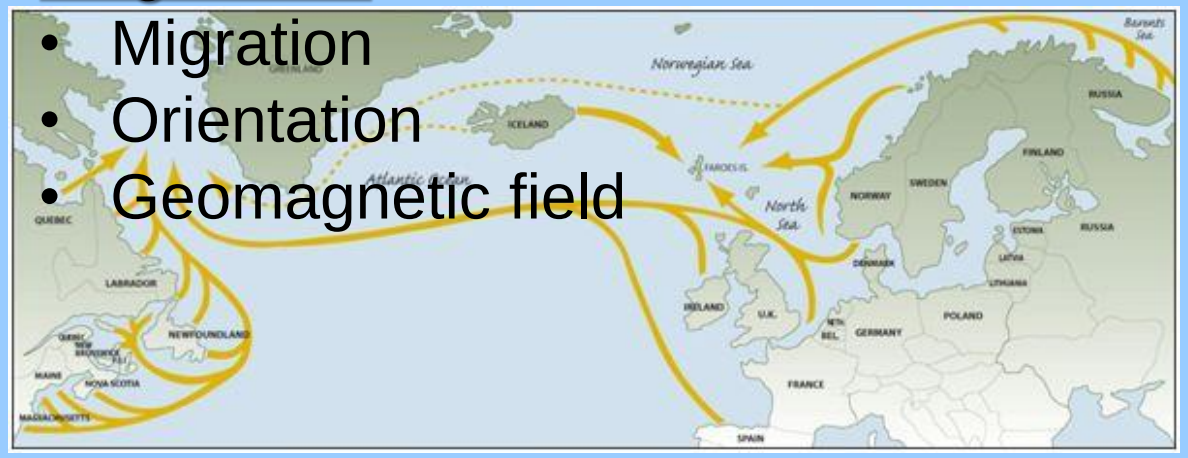

Source: Walter Baxter


Source: ABGill

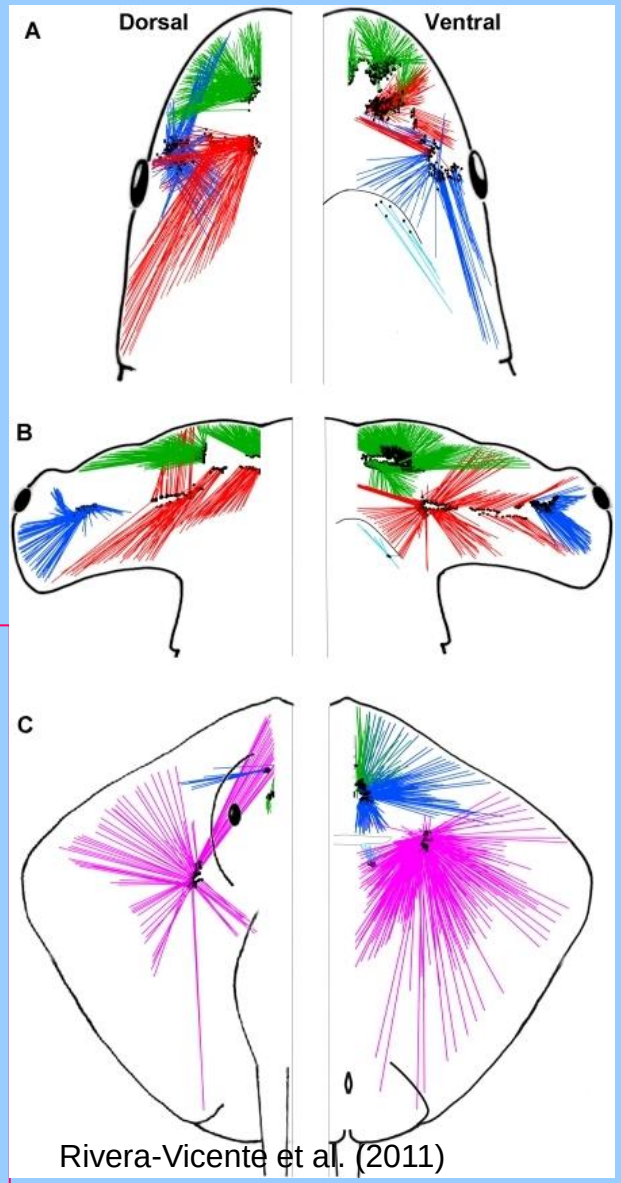
Scale of animal interaction with E-M fields

Large scale

- Migration
- Orientation
- Geomagnetic field



Source: Atlantic Salmon Federation http://www.asf.ca/about_salmon.php

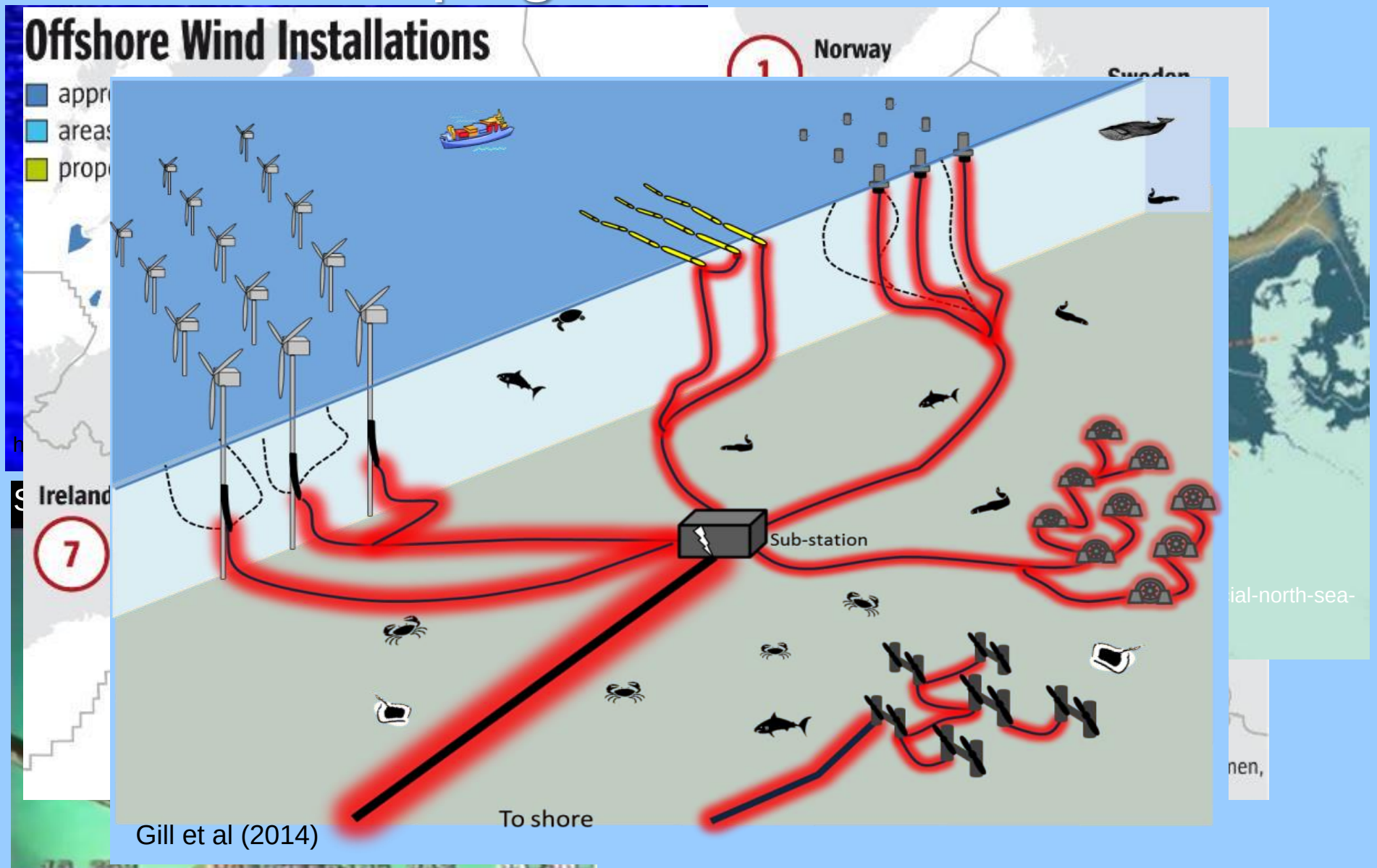


Rivera-Vicente et al. (2011)

Fine scale

- Electroreception
- Prey, mates
- Orientation
- Sensory ability in several species groups

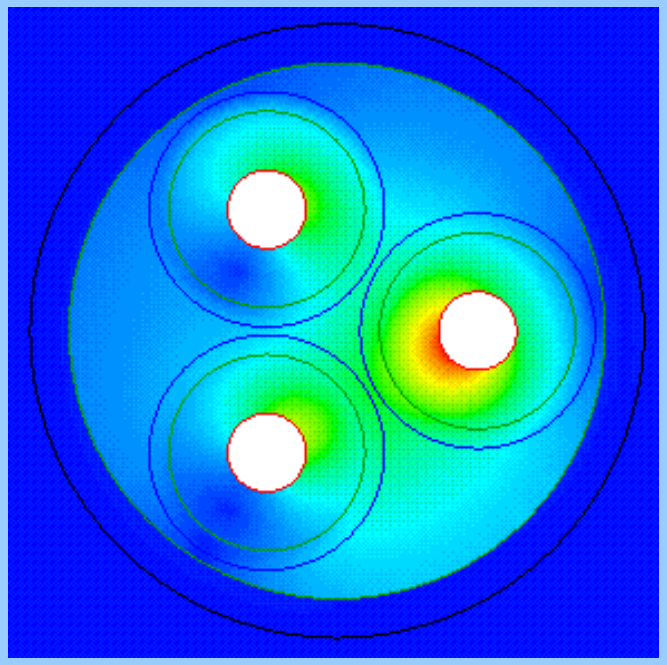
Anthropogenic EMF sources



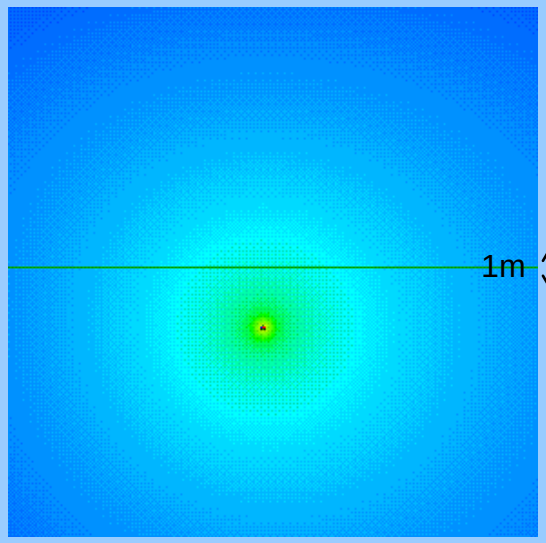
Gill et al (2014)

https://i.ytimg.com/vi/XMxkRh7sx84/0.jpg

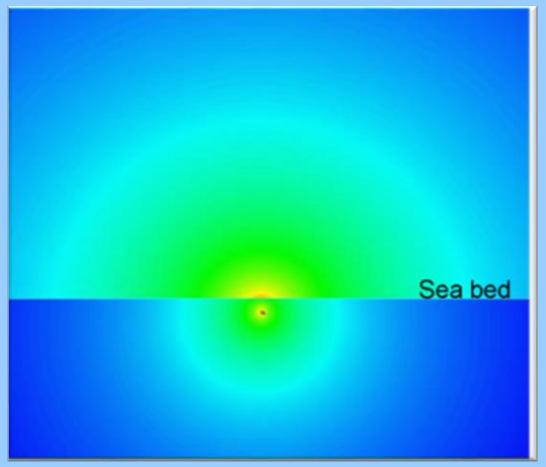
Anthropogenic Electromagnetic field (EMF) - FEM predicted emissions from A.C. subsea cables



X-section AC cable (internal) – magnetic field



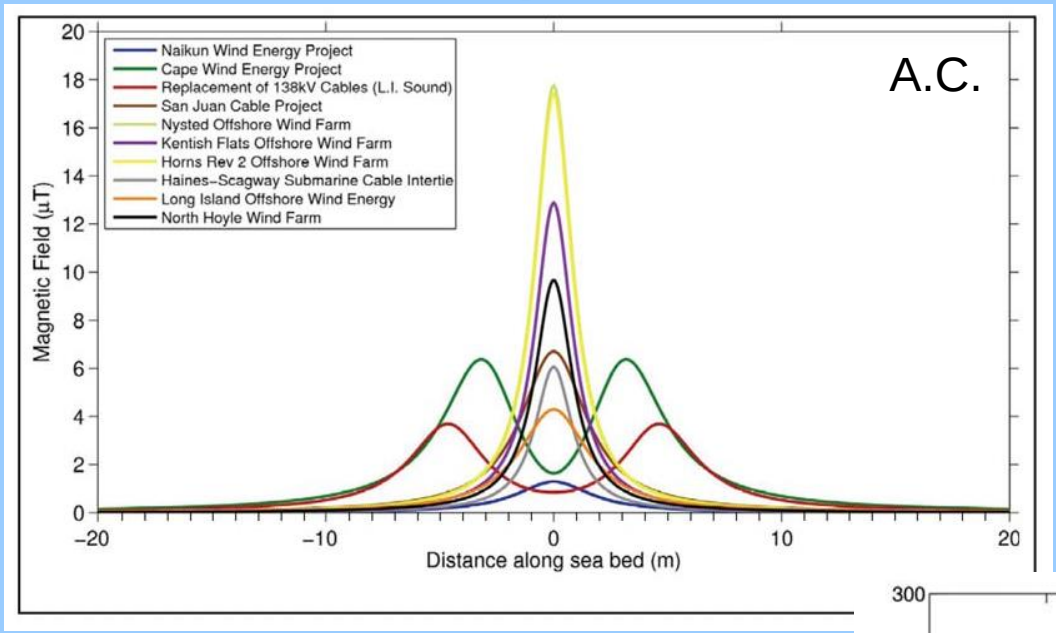
X-section cable (external) - magnetic field



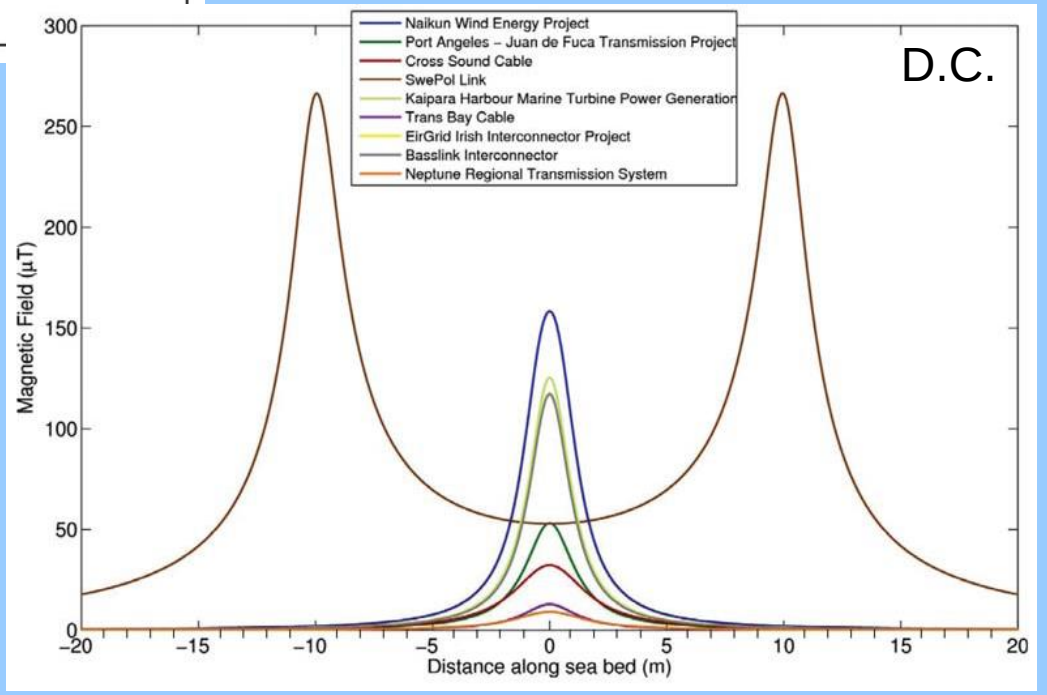
X-section cable (external) - induced electric field

Gill et al (2012a)

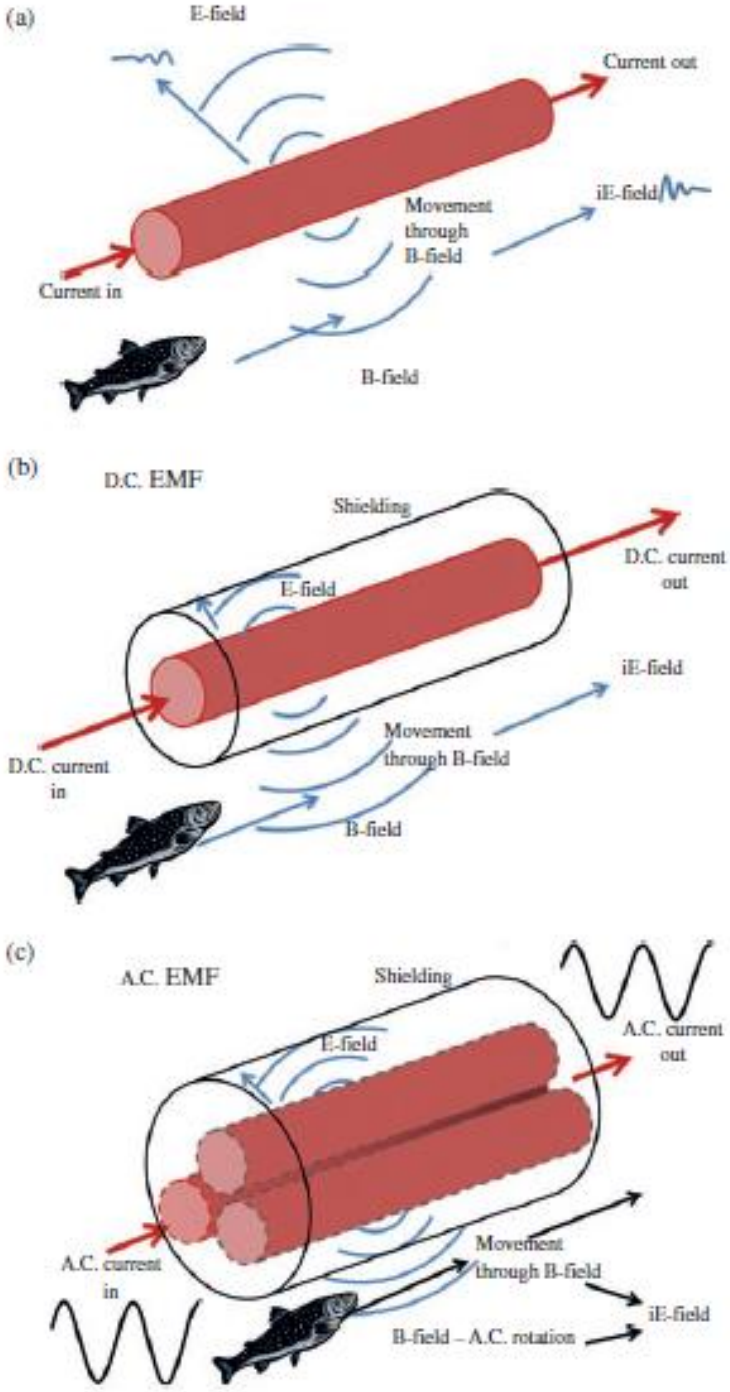
EMF dissipation – A.C. & D.C. models



From: Normandeau et al (2011)



Defining the EMF environment – AC and DC for biological relevance



Gill et al (2012b)

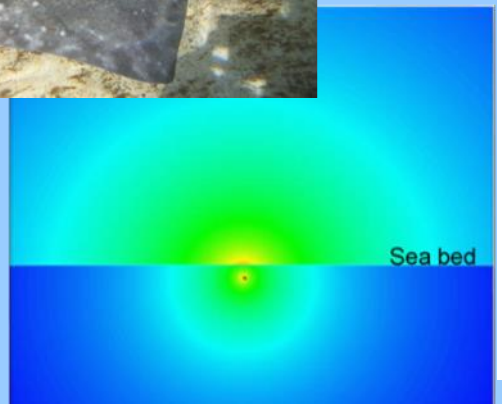
Environmental legislation – EMF specific

Descriptor of Good Environmental Status under the EU's Marine Strategy Framework Directive (MSFD) for inputs of energy Article 11. The full text of the descriptor is:

Introduction of energy, i
adversely affect the mar

- Several anthropogenic based s
environment - sound, light, ele

EU Habitats Directive -



Protection of species

Article 12

1. Member States shall take the requisite measures to establish a system of strict protection for the animal species listed in Annex IV (a) in their natural range, prohibiting:

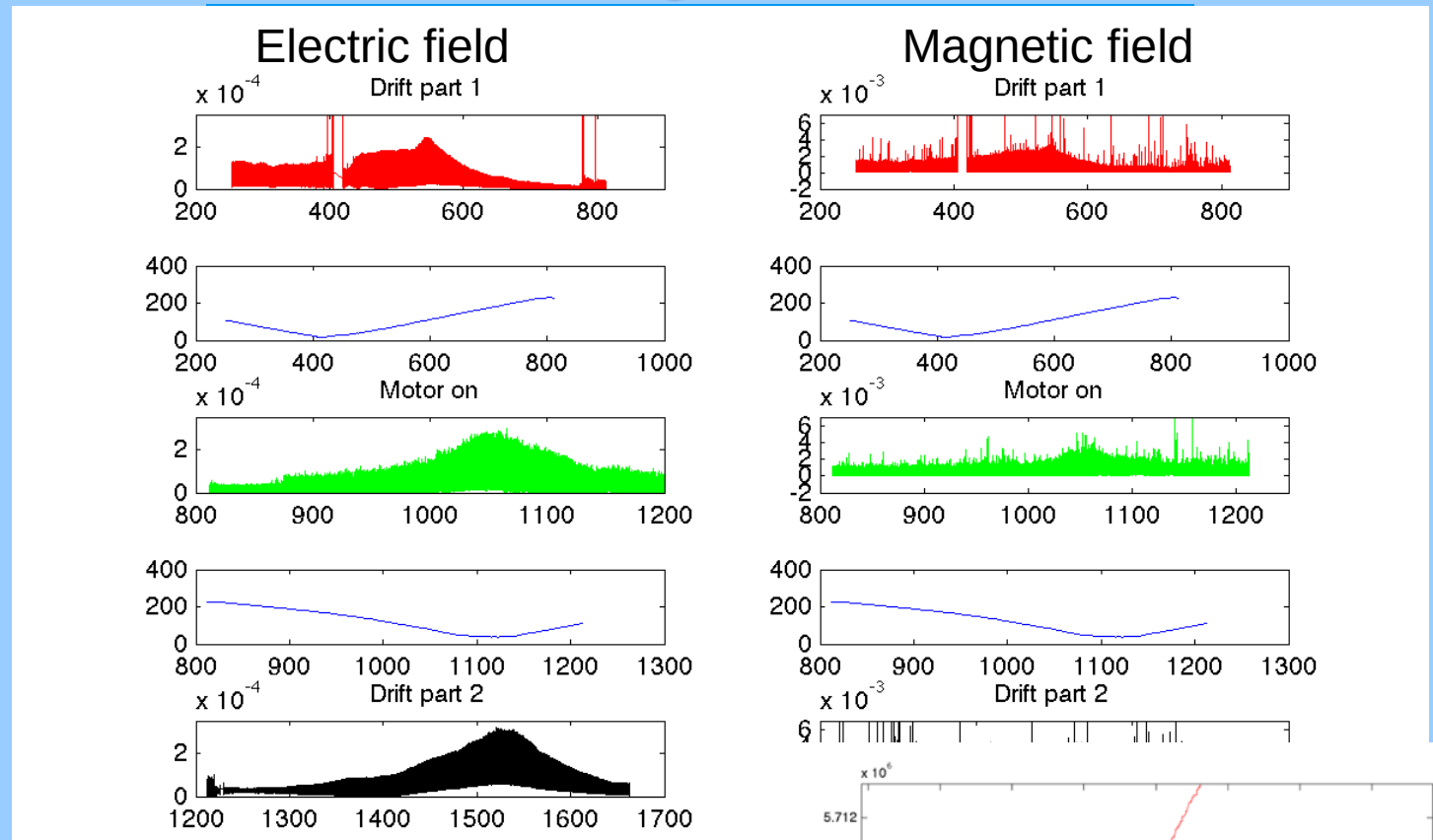
(a) all forms of deliberate capture or killing of specimens of these species in the wild;

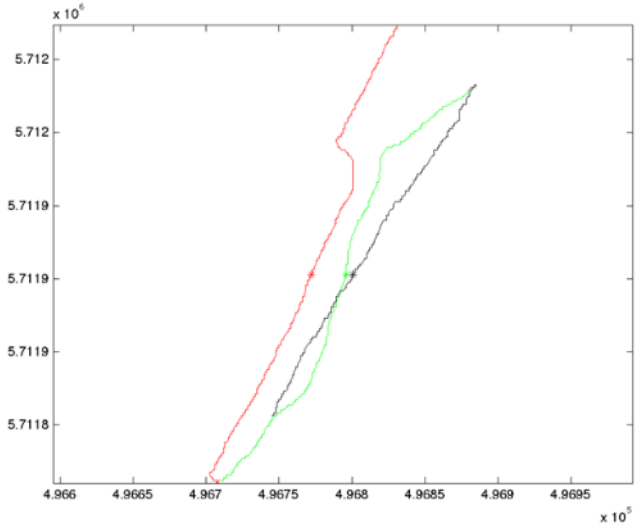
(b) deliberate disturbance of these species, particularly during the period of breeding, rearing, hibernation and migration;

(c) deliberate destruction or taking of eggs from the wild;

(d) deterioration or destruction of breeding sites or resting places.

EMF at Belgian wind farm





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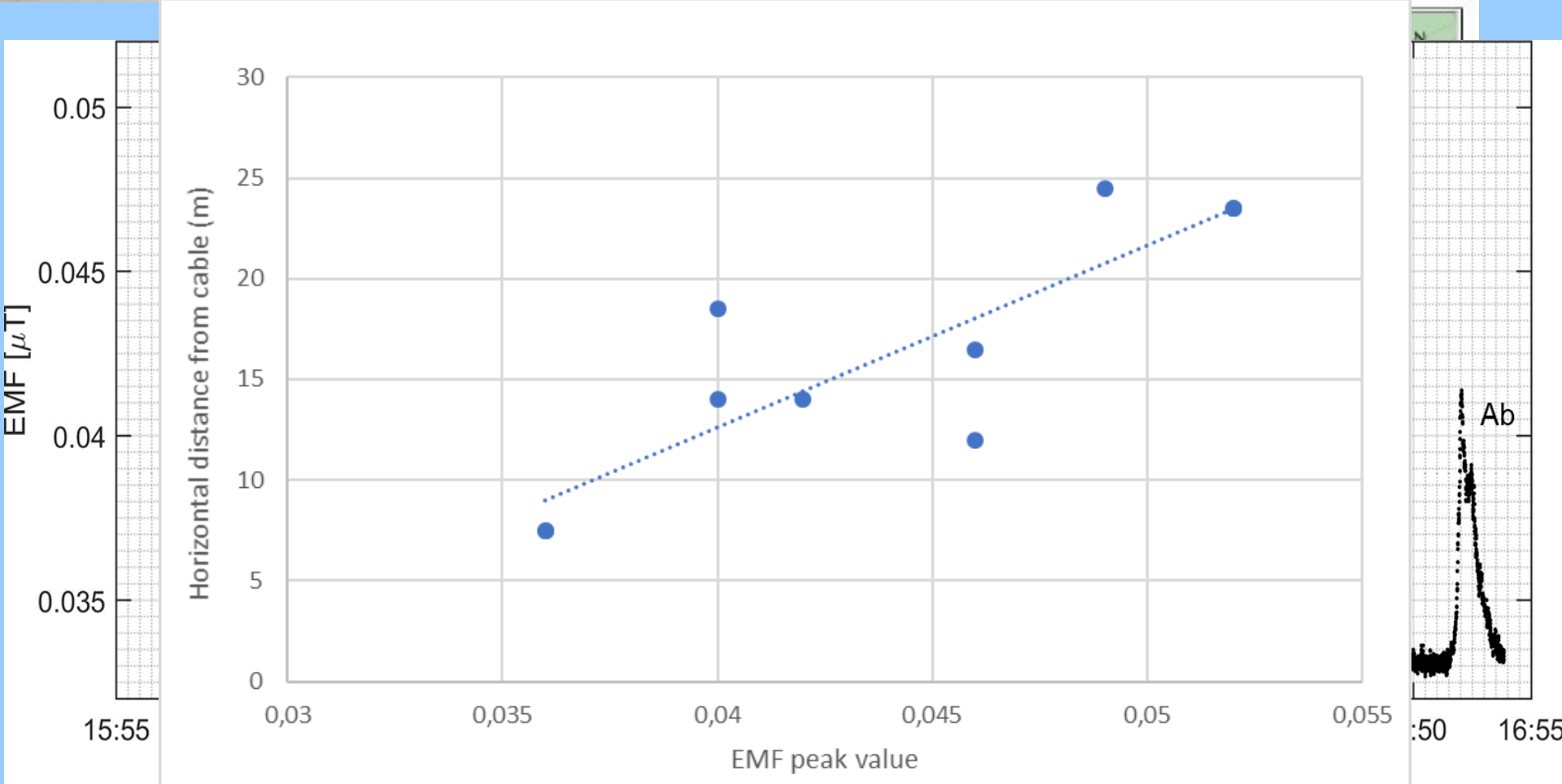
-8529-

Table 2.2 Overview of three wind parks with corresponding AC undersea export cables, used for this study.

Wind park	Electric power capacity at full production	Voltage
LUD	129 MW	150 kV
PAWP	120 MW	150 kV
OWEZ	108 MW	3 x 34 kV

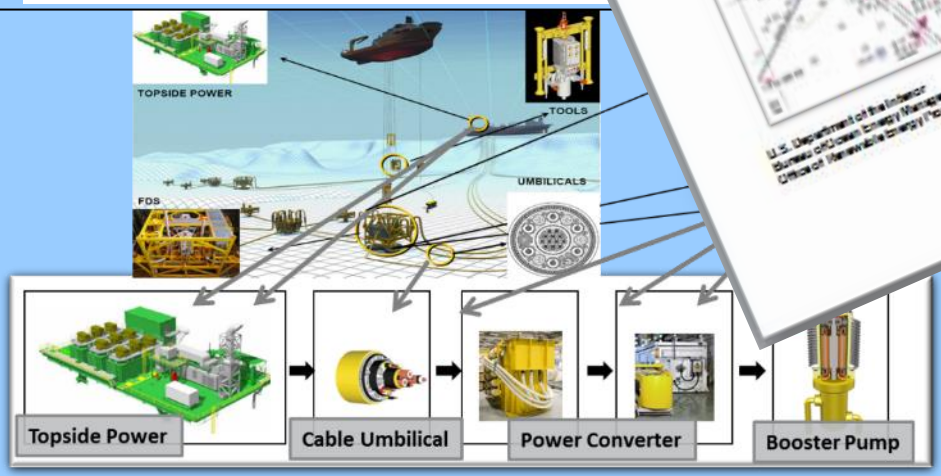
The study area and location of the measured cables is shown in Figure 2.3.



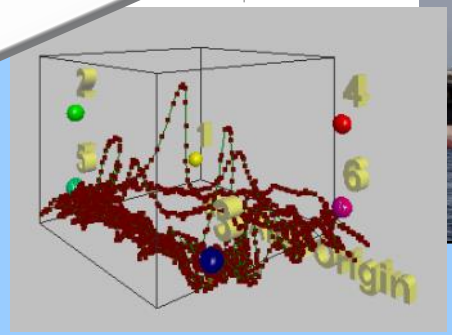
BOEM - EMF effects from HVDC on migratory species

1. Determination of EMF emitted

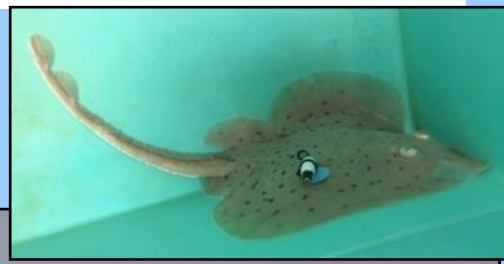
2. Evaluation of power sy
w.r.t environmental conditi



An example of subsea power distribution network (Figure courtesy: ANSYS)

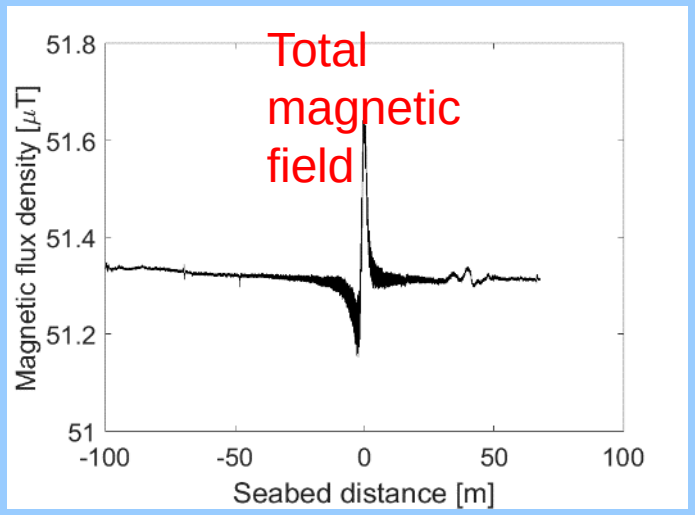


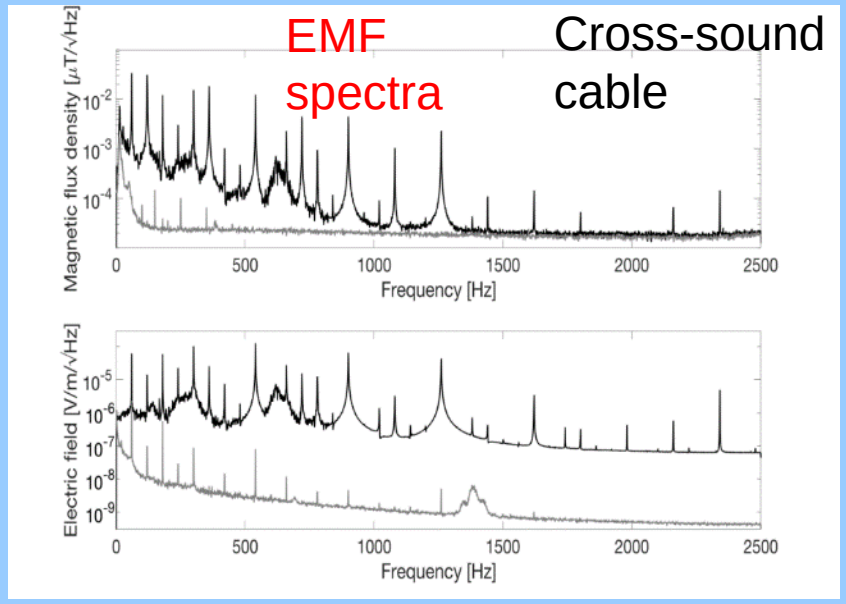
3. Response of species to encounter with EMF emitted

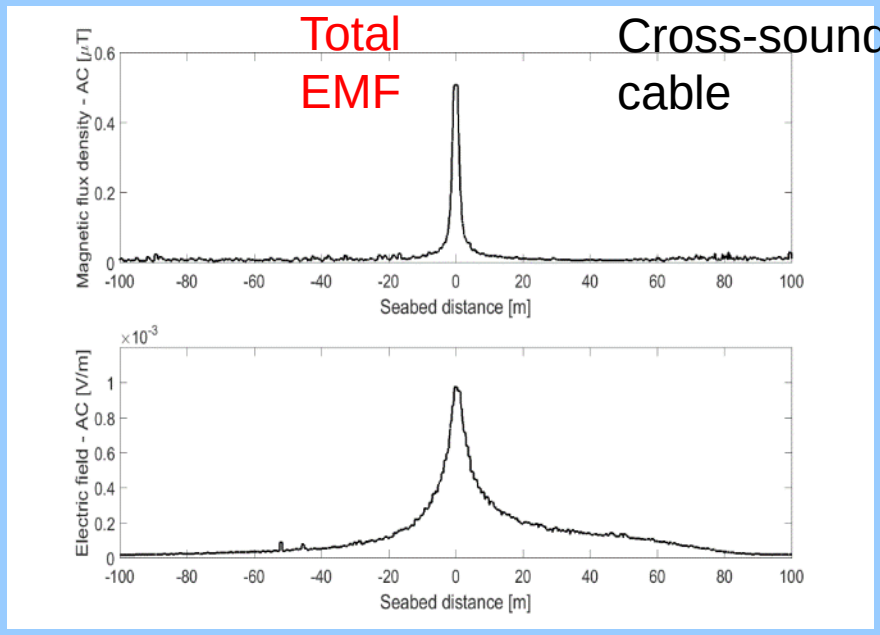


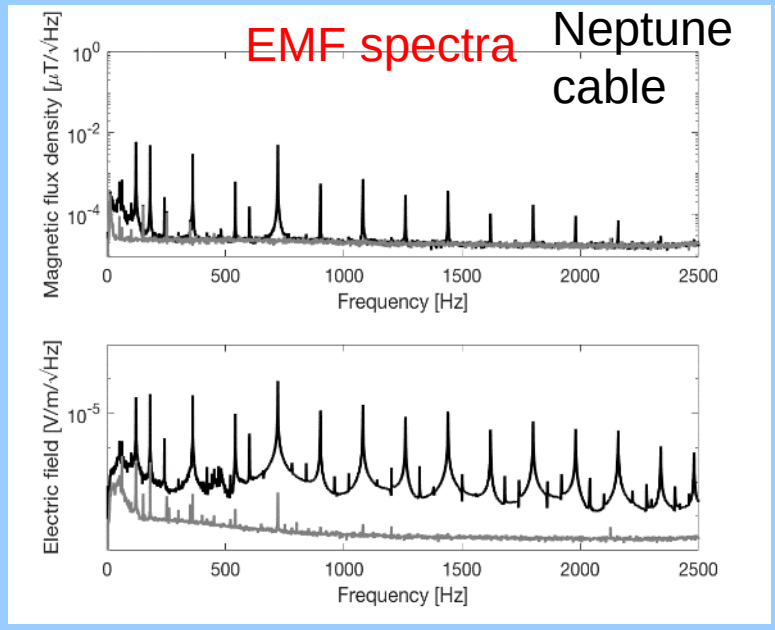
Cranfield UNIVERSITY

1. Determination of EMF emittedfrom HVDC power cables, USA









3. Response of species to encounter with EMF emitted - Summary

Response (effect) + distribution

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Spat

MF

MF

www.nature.com/scientificreports

Scientific Reports | *(2020) 10:4219* |
https://doi.org/10.1038/s41598-020-60793-x

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Anthropogenic electromagnetic fields (EMF) influence the behaviour of bottom-dwelling marine species

Zoë L. Hutchison[1*], Andrew B. Gill[2,3*], Peter Sigray[4], Haibo He[5] & John W. King[1]

Field study evidence

Westerberg & Lagenfelt (2008)

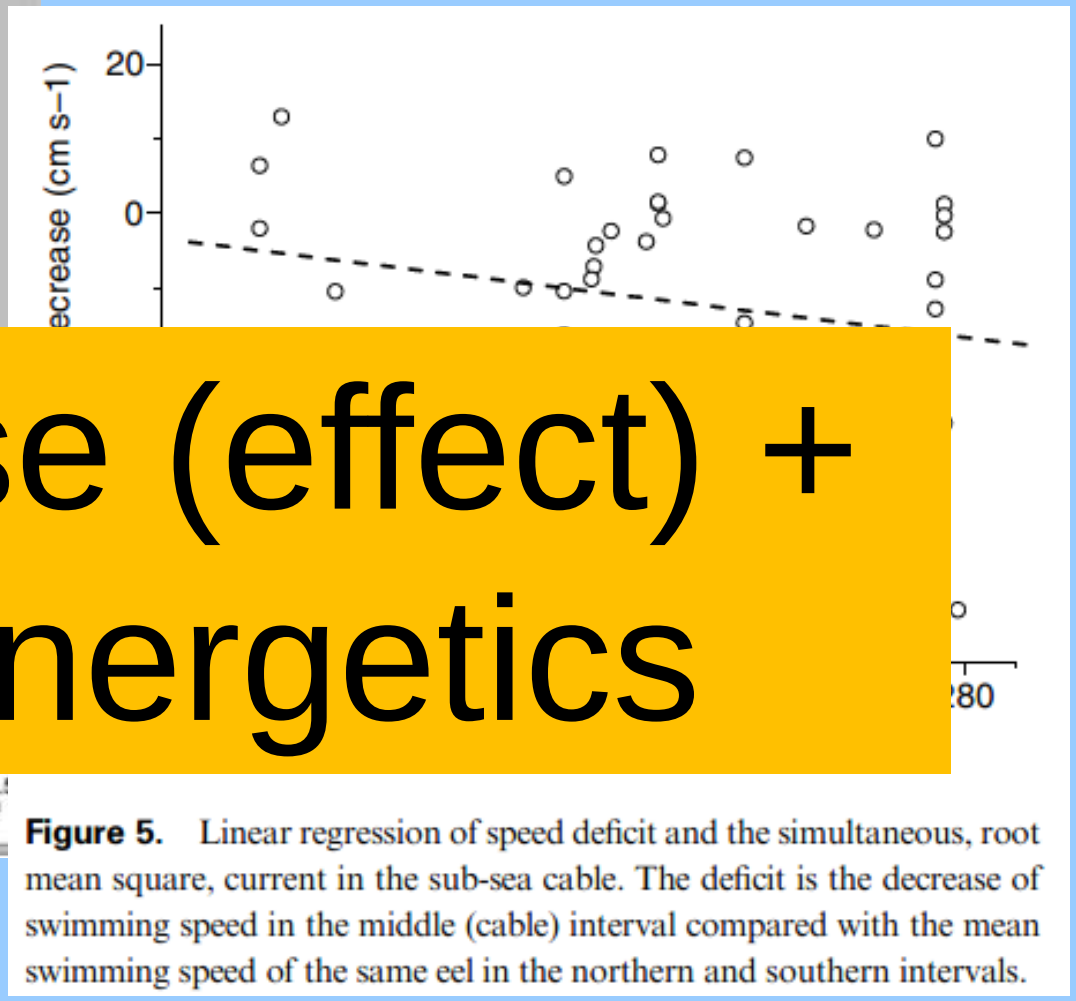


Figure 5. Linear regression of speed deficit and the simultaneous, root mean square, current in the sub-sea cable. The deficit is the decrease of swimming speed in the middle (cable) interval compared with the mean swimming speed of the same eel in the northern and southern intervals.

Response (effect) + animal energetics

Measured and Observed Effect of E & M Fields (e.g.'s)

Effect	Type of response*	Taxa	D.C. /A.C	Field /Lab
Electrosensitive species altered behaviour and distribution to cables .	B	Fish	DC , AC	Field
Magnetosensitive species altered behaviour exposed to cable	B	Fish, Invertebrates	DC	Field
Higher abundance at the sites when cable power was off	B	Fish	DC, AC	Field
Higher proportions of migrators crossed cable location and were more likely to be detected south of normal migration route	B	Fish	DC	Field
Decreased movement activity / alarm response	B	Fish Invertebrates	DC, AC	Lab
Decreases in melatonin levels[1]	P	Fish	DC	Lab
Delay in egg developmental /larval respiration	D, P	Fish; Invertebrates	DC, AC	Lab
Reduced growth and development	D	Fish[2]	DC	Lab
Enhanced yolk-sac absorption rate in larvae	D, P	Fish	AC	Lab

Notes: * Behavioural (B), Developmental (D), Physiological (P)

[1] Hormonal tests did not give any evidence of stress

[2] California halibut (different family) no noticeable effects

Some other studies no measurable effect

Subsea cables - Biological Impact Framework

Define EMF

- **Electric or Magnetic**
- **Type (AC / DC)**
- **ambient context**

Potential Receptors of emitted EMF

Marine/aquatic mammals & turtles	Fish (telelosts & elasmobranchs)	Marine/aquatic invertebrates

Effect

Movement & distribution			*Life history*		
Altered Migration - large scale	**Movement pattern - Medium scale**	**Avoidance or attraction - Small scale**	**Early life stage development**	**Physiological / biochemical change (e.g.. Energetic)**	**Prey /predator detection**

Likelihood of encounter with EMF = # cables + EMF emission extent

Impact

Population level change - manifest through health, survival &/or reproductive success on target species

What does the context & available evidence tell us about EMF associated with Subsea cables

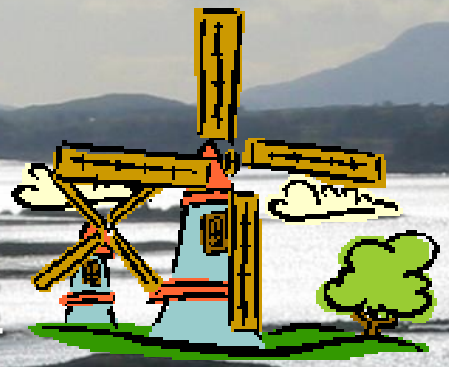
- Subsea cables WILL emit EMF that some sensitive organisms WILL respond to. (= EFFECT)
  - seabed species, closer to the source, most likely to encounter higher intensities
- HV DC cables emit larger EMF than AC but context of how animals will respond needs defined to determine any impact (or not)
  - single HV AC or DC cable no impact expected (medium confidence)
  - low power – small EMF (scales up with power)
  - lack of knowledge when considering future expansion plans to arrays
- Responses demonstrated but extrapolation to impacts of EMF on sensitive receptors is speculative
- EMF (magnetic field) can be measured using commercial magnetometer – (need more data to validate models)
  - EMF (electric field) difficult to measure – (need method + data)
- Targeted collaborative activity and research essential, building knowledge based (i.e. adapt with new knowledge)

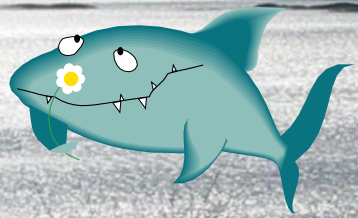
THANKS to:
All colleagues working on EMF
University Rhode Island; FOI – Swedish Defence Agency; Cranfield University; Liverpool University; Witteveen+Bos, WaterProof, Bureau Waardenburg-Netherlands; Cross-Sound Cable Co.
Funders: BOEM, USA; EC, Europe; COWRIE, UK;

Thanks

&

Very happy to talk further :





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