Offshore Wind farms and environment

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Time phases

- Installation [High potential impact]:
  - Substrate
  - Turbid plume
  - Acoustic impact
- Exploitation [Low potential impact]:
  - Sacrificial anode
  - Electromagnetic fields
  - Reef effect or FAD (Fish Aggregating Devices) ?
- Dismantling ?

Low impact with floating wind turbines

New substrate = faunal modification

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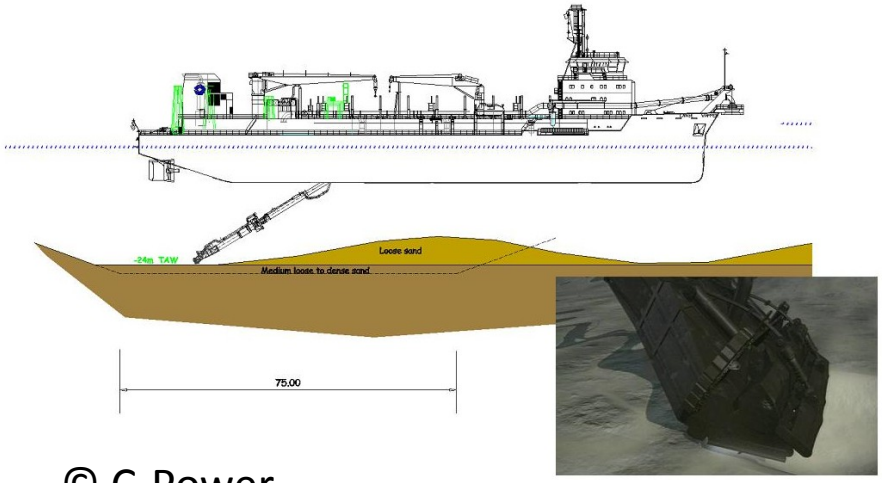

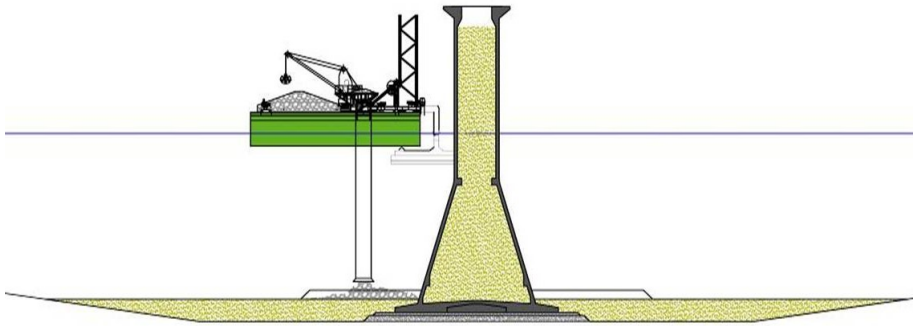

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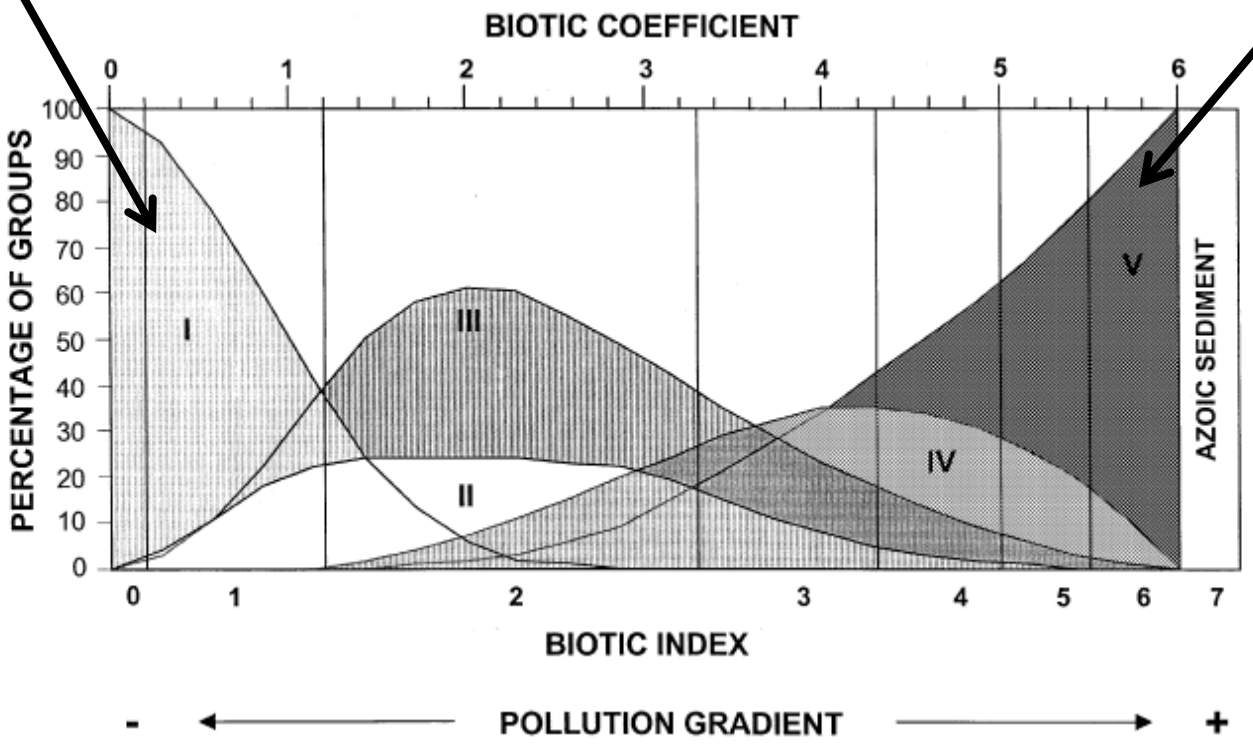
Turbid plume = faunal modification

Sensible species

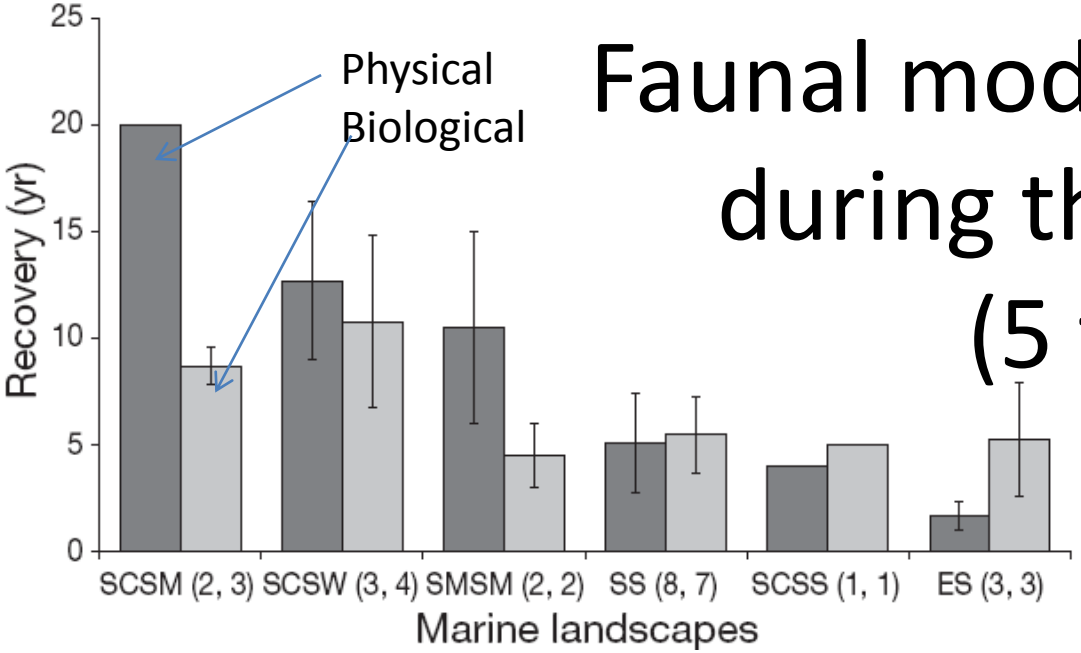
Opportunistic species



Biotic indexes used for the WFD (AMBI, BENTIX, …) are based on the modification of the organic matter content

↗[Mud] = ↗ [Organic Matter] = ↗ opportunistic species & ↘ sensible species

Faunal modification isn't only during the construction (5 to 10 yrs)



(Foden *et al.*, 2009)

Table 1. Marine landscape types in UK waters, targeted by the aggregates sector. Wave base is 50 to 70 m. Tide stresses: weak = 0 to 1.8 N m^{-2}, moderate = 1.8 to 4.0 N m^{-2}, and strong is >4.0 N m^{-2}. UKCS: UK continental shelf (from Connor et al. 2006). Slope is negligible (<2 %) for the shallow and shelf plain. Estuary has a strong salinity gradient from riverine inputs

Marine landscape type (depth) Substratum	Tide stress (currents)	Abbrev.	Area (km^2)	Prop. of total UKCS
Estuary (0 to 30 m)				
Mainly soft sediment, limited rock	Variable; moderate to strong in channels	ES	2881	0.3
Shallow plain (coastline to wave base)				
Coarse sediment	Weak	SCSW	33 694	3.9
	Moderate	SCSM	16 745	1.9
	Strong	SCSS	7869	0.9
Mixed sediment	Moderate	SMSM	2021	0.2
Sand / muddy sand	Variable	SS	48 218	5.5
Shelf plain (wave base to 200 m)				
Coarse sediment	Moderate	SHCM	17 433	2.0
	Strong	SHCS	2840	0.3
Mixed sediment	Moderate	SHMM	2260	0.3
Sand / muddy sand	Variable	SHSP	215 215	24.7

Acoustic impact: Marine mammals and fishes are sensible

Frequency	Group	Audibility	Threshold
ultrasonic	Dolphins, porpoises	200 Hz to 200 kHz	40 dB re 1µPa
Ultrasonic to sonic	Seals	1 kHz to 20 kHz	50 dB re 1µPa
Sonic to infrasonic	Whales	15 Hz to 20 kHz	60-80 dB re 1µPa ?

(Ketten, 1998)

Pile driving can damage fish swim bladder and rupture internal organs, disorient the marine mammals over long distances

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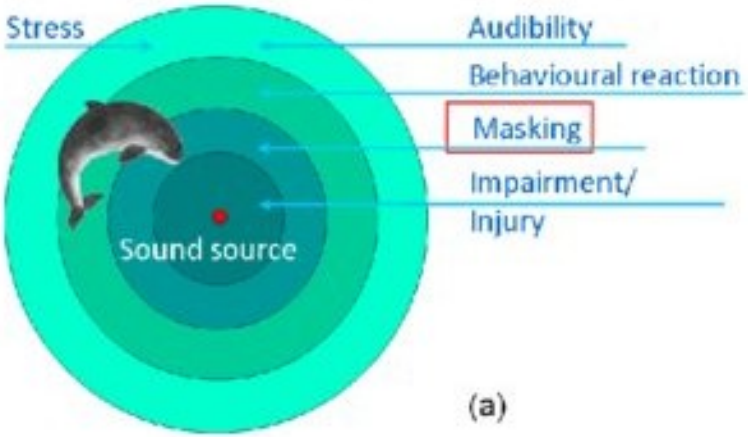


(Audoly and Rousset, 2014)

Acoustic impact: Bubble curtains can be required to reduce noise

Impressed current system has less impact

acrificial anode

94 % Al

5 % Zn

0,12 % Si

0,09 % Fe

0,03 % In

0,003 % Cu

0,002 % Cd

(Yark *et al.*, 2016)

39,5 t/yr disolved to protect a wind farm with 62 turbines

Contamination of sediments, benthic organisms and fishes

Electromagnetic fields

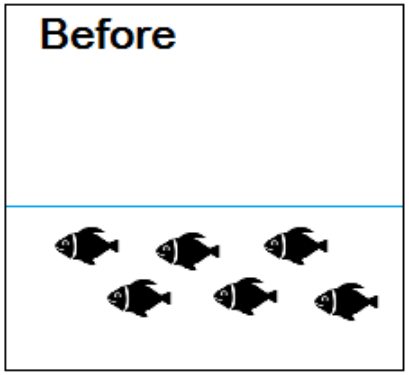
- Effects are space limited
- Behavioral and physiological effects (Öhman *et al*., 2007)
- Well documented for fishes, elasmobranchs and marine mammals but few documented for benthic invertebrates, except for commercial species

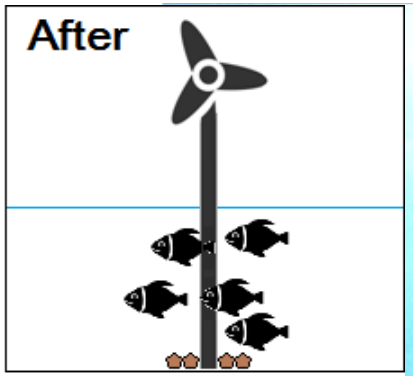
Species	Common name	Conservation status	Frequency in Scottish and UK Waters	Evidence of response to E fields	Evidence of response to B fields
Anguilla anguilla	European eel	Critically Endangered	Common	✓[1,2]	✓[3,4]
Salmo salar	Atlantic salmon	Least Concern	Common	✓[5,6]	✓[5,6]
Salmo trutta	Sea trout	Least Concern	Occasional		✓[7]
Pleuronectes platessa	European plaice	Vulnerable	Common	✓[8]	✓[8]
Thunnus albacares	Yellowfin tuna	Least Concern	Occasional		✓[9-12]
Lampetra fluviatilis	European river lamprey	Near Threatened	Common	✓[13,14]	
Petromyzon marinus	Sea lamprey	Least Concern	Occasional	✓[15-17]	

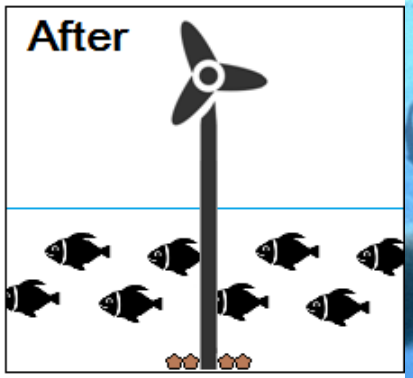
[1] Berge (1979); [2] Vriens & Bretschneider (1979); [3] Enger *et al.* (1976); [4] Westerberg (1999); [5] Moore *et al.* (1990); [6] Rommel & McCleave (1973); [7] Formicki *et al.* (2004) – *juvenile fish*; [8] Metcalfe *et al.* (1993); [9] Kobayashi & Kirschvink (1995); [10] Walker *et al.* (1984); [11] Walker (1984); [12] Yano *et al.* (1997); [13] Gill *et al.* (2005); [14] Akeov & Muraveiko (1984); [14] Bodznick & Northcutt (1981); [15] Bodznick & Preston (1983); [16] Bowen *et al.* (2003); [17] Chung-Davidson *et al.* (2004)

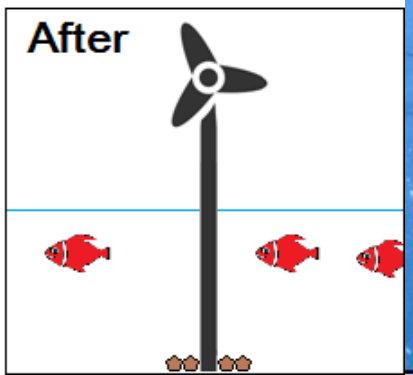
Snoek *et al*., 2016)

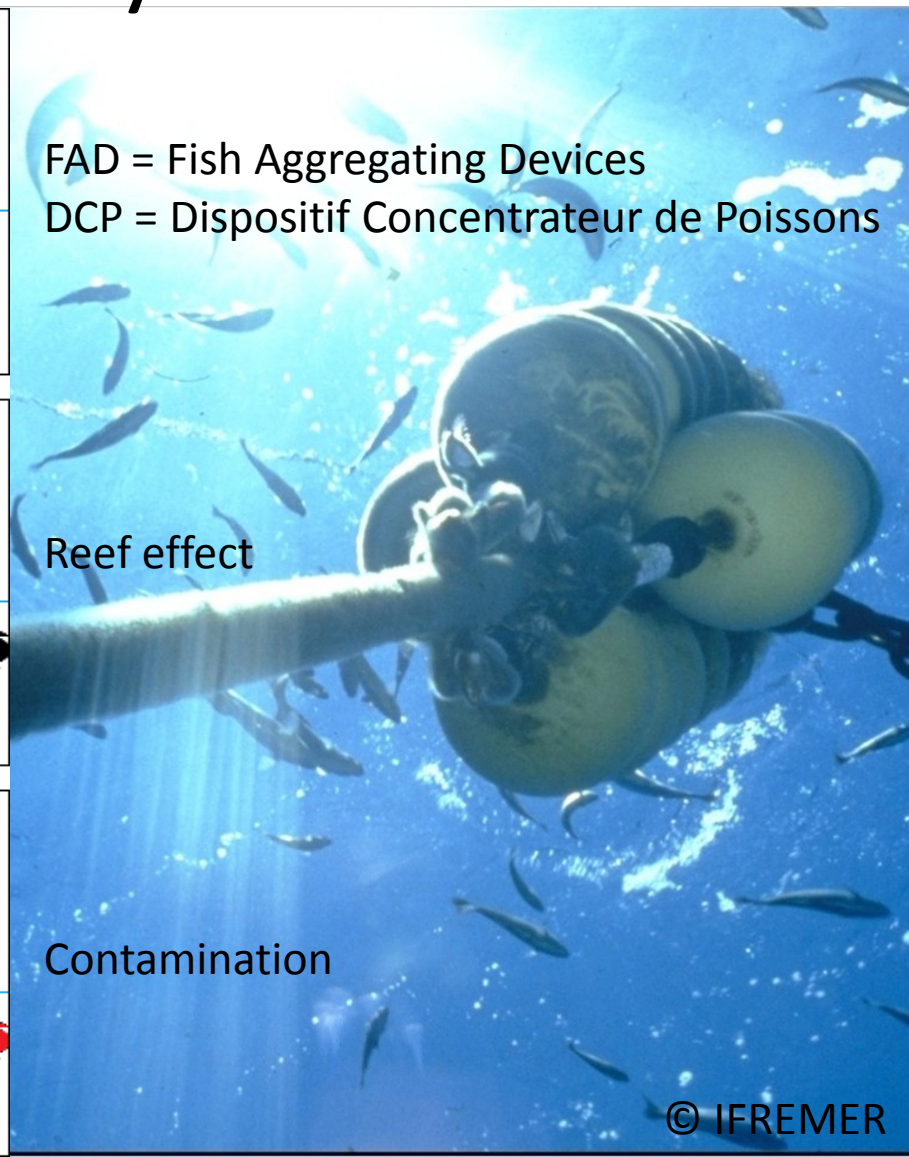
Reef effect or FAD?: Site by site study necessary











Dismantling ?

- The great unknow : How to dismantle?

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