

TURBINES TO REEFS

FLOATING OFFSHORE WIND 2025, ABERDEEN

A photograph of a floating offshore wind turbine in the ocean. The turbine has a white tower and three blades. Its substructure consists of yellow cylindrical floats connected by yellow beams. A red and white service vessel is positioned nearby. The sky is overcast. A large green triangle with a white border is on the right side of the image.

STARKCOAST

consulting

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1. Rigs-to-Reef and the Prevalence of Artificial Reefs
2. Hard Substrate
3. The Theory of Island Biogeography and Manmade Structures
4. What Does the UKCS look like in 2060?



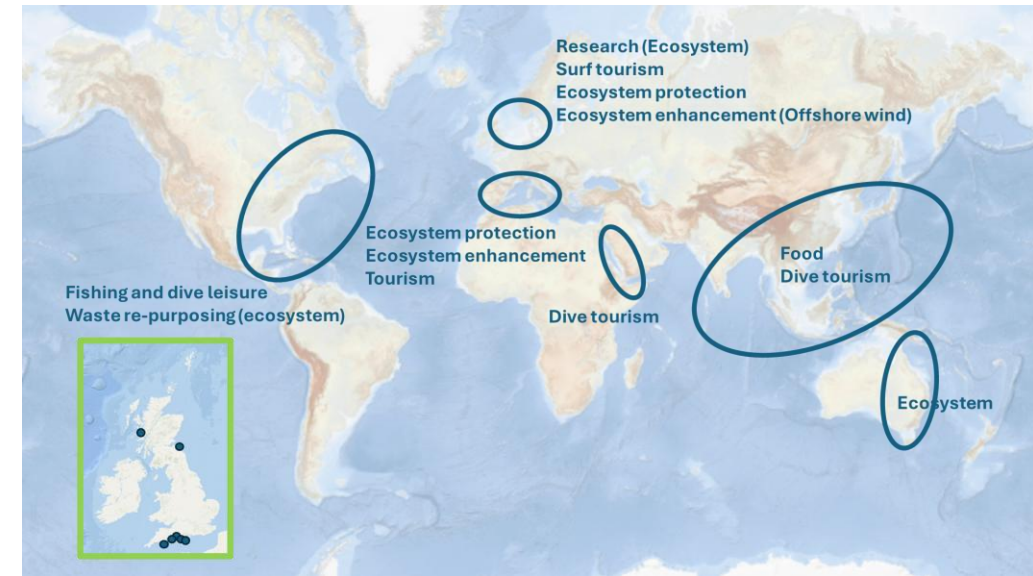
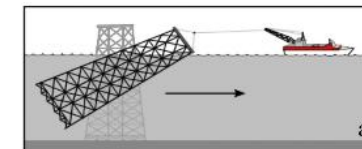
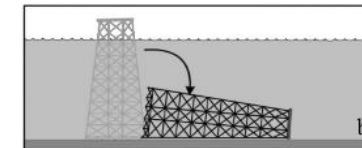
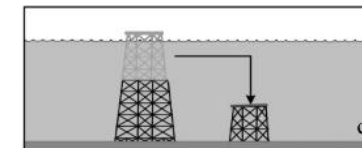
Artificial Reefs (AR) & Rigs-to-Reef (R2R)

Artificial Reefs

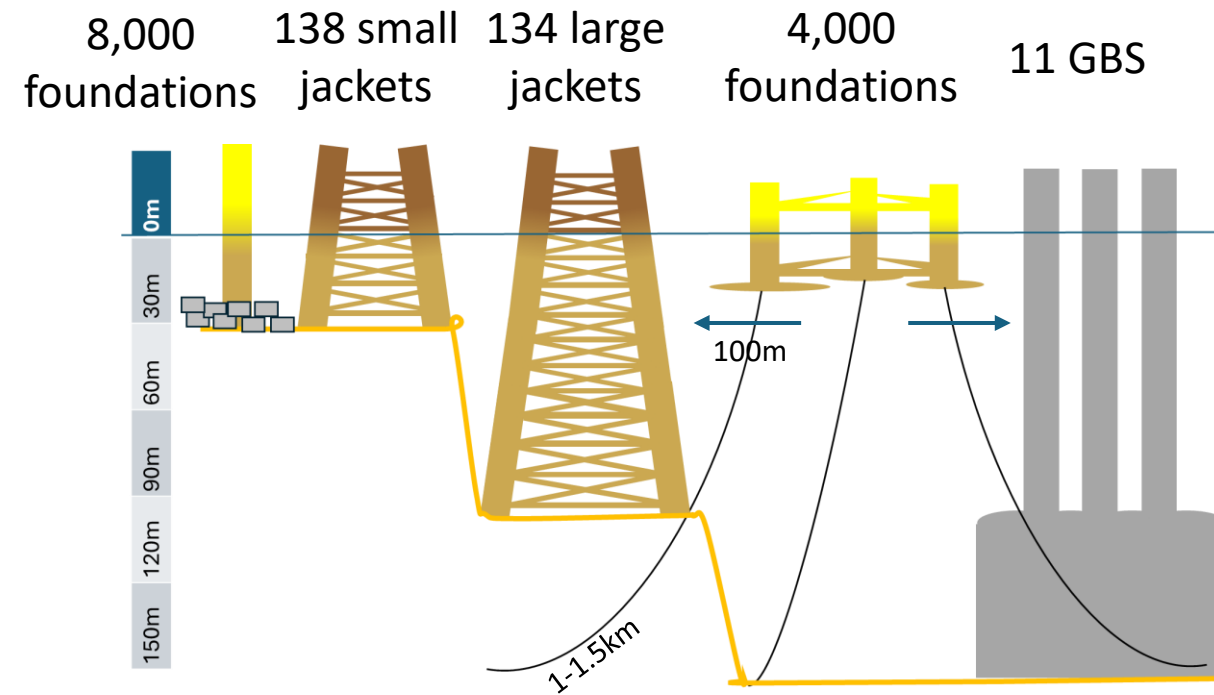
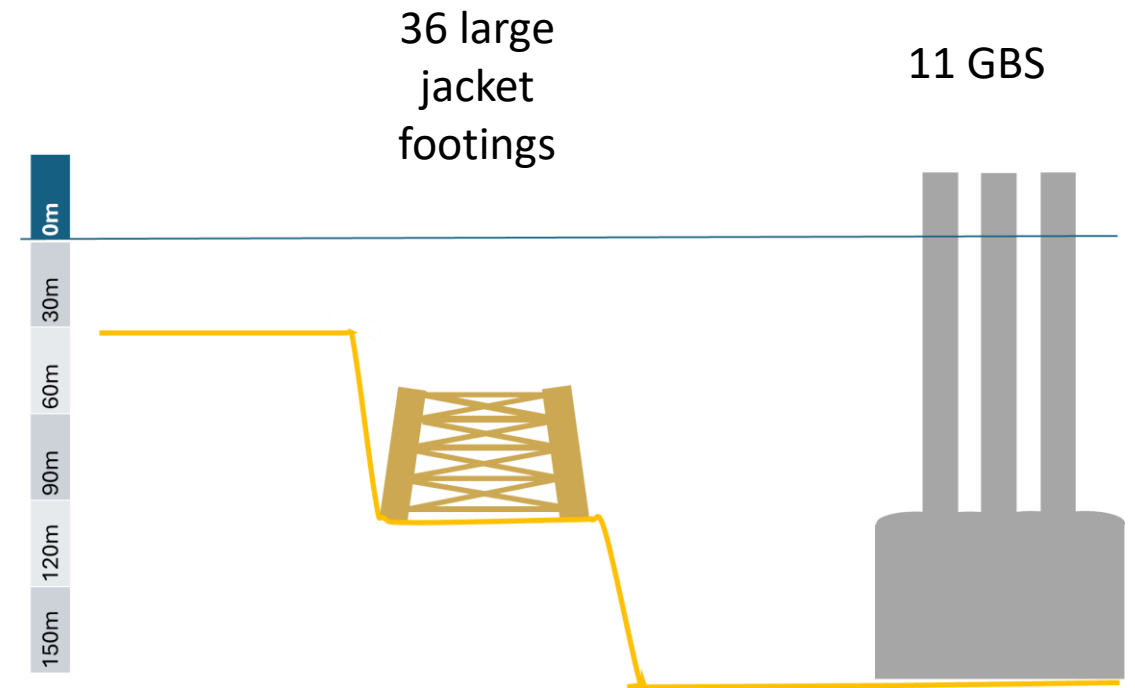
- Found in 151 countries/dependencies (49%)

Rigs-to-Reef

- GoM ~ 600 platforms (~20%)
- Brunei, Malaysia & Japan <10
- Thailand, Australia and Angola tbc



Hard Substrate – Pre and Post Decom (today)



Islands of Biodiversity

Footprint

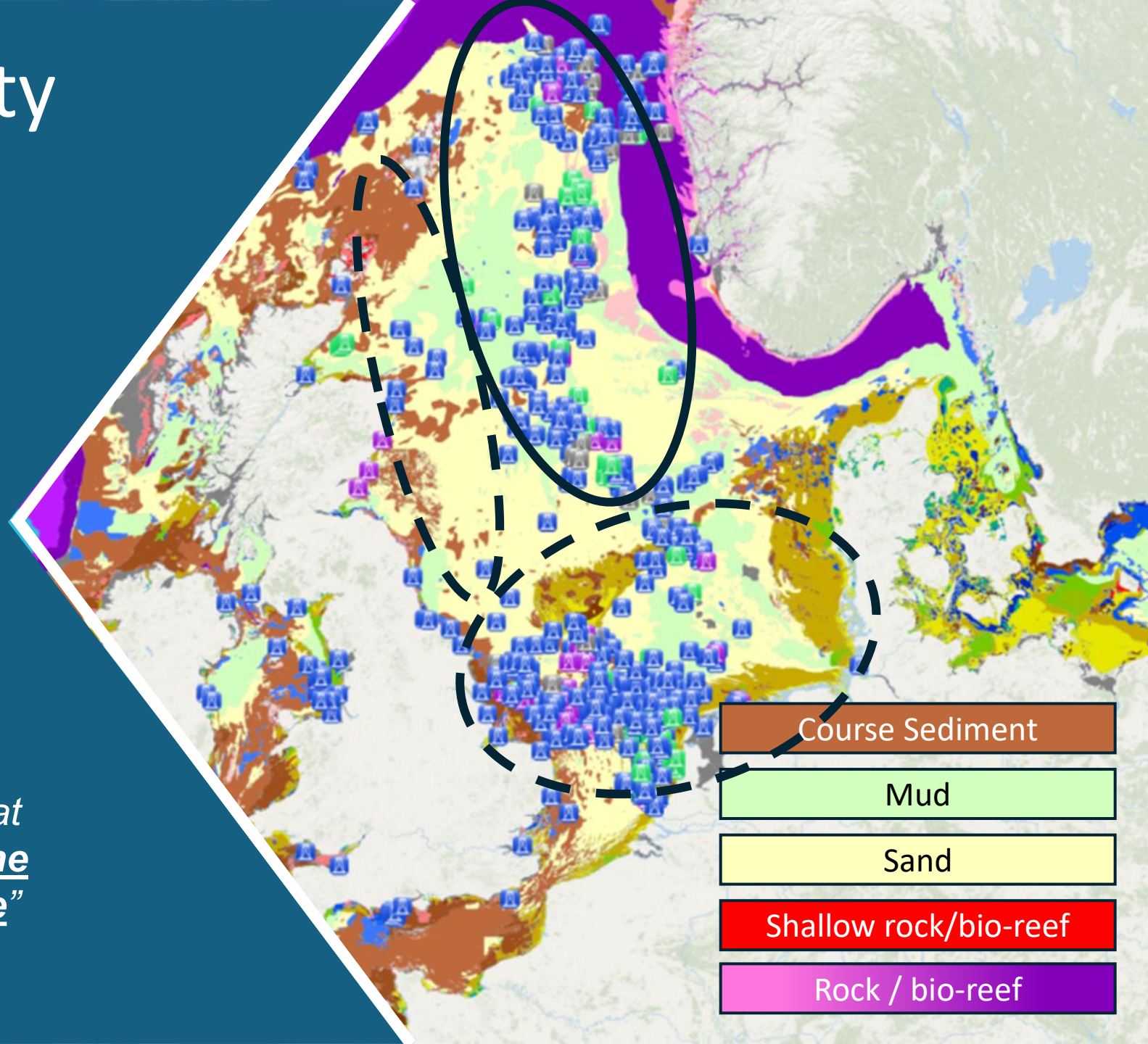
- SNS – 0.0025km²
- CNS NNS – 0.1km²
- 500m Safety Zones = 0.78km²
- UKCS / UKEEZ = 773,000km²

‘Islands of Biodiversity’

‘Stepping Stones’

‘Defacto Marine Protected Areas’

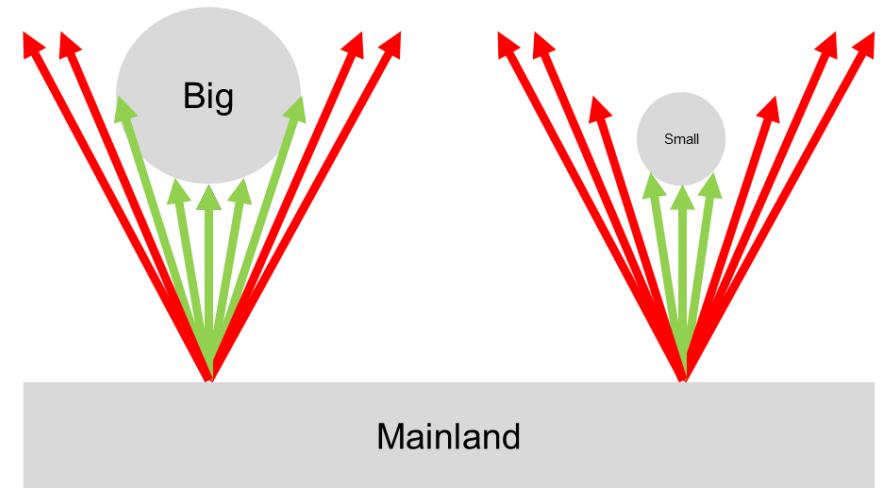
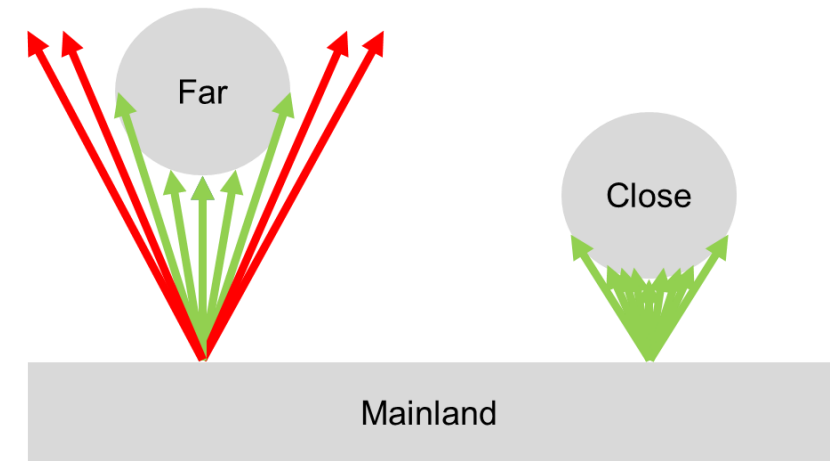
*“It is not the strongest of the species that survives, nor the most intelligent, **but the one that is most adaptable to change**”*
(Quote incorrectly attributed to Darwin!)



Island Biogeography

Island populations and diversity are a function of island size and connectivity (isolation)

- Size
 - Surface area
 - Protection
- Distance
 - Colonisation from the 'mainland' / other islands
- Resources
 - Food, mates, shelter
 - Rescue Effect
- Equilibrium
 - Species immigration = extinction
 - Spill over



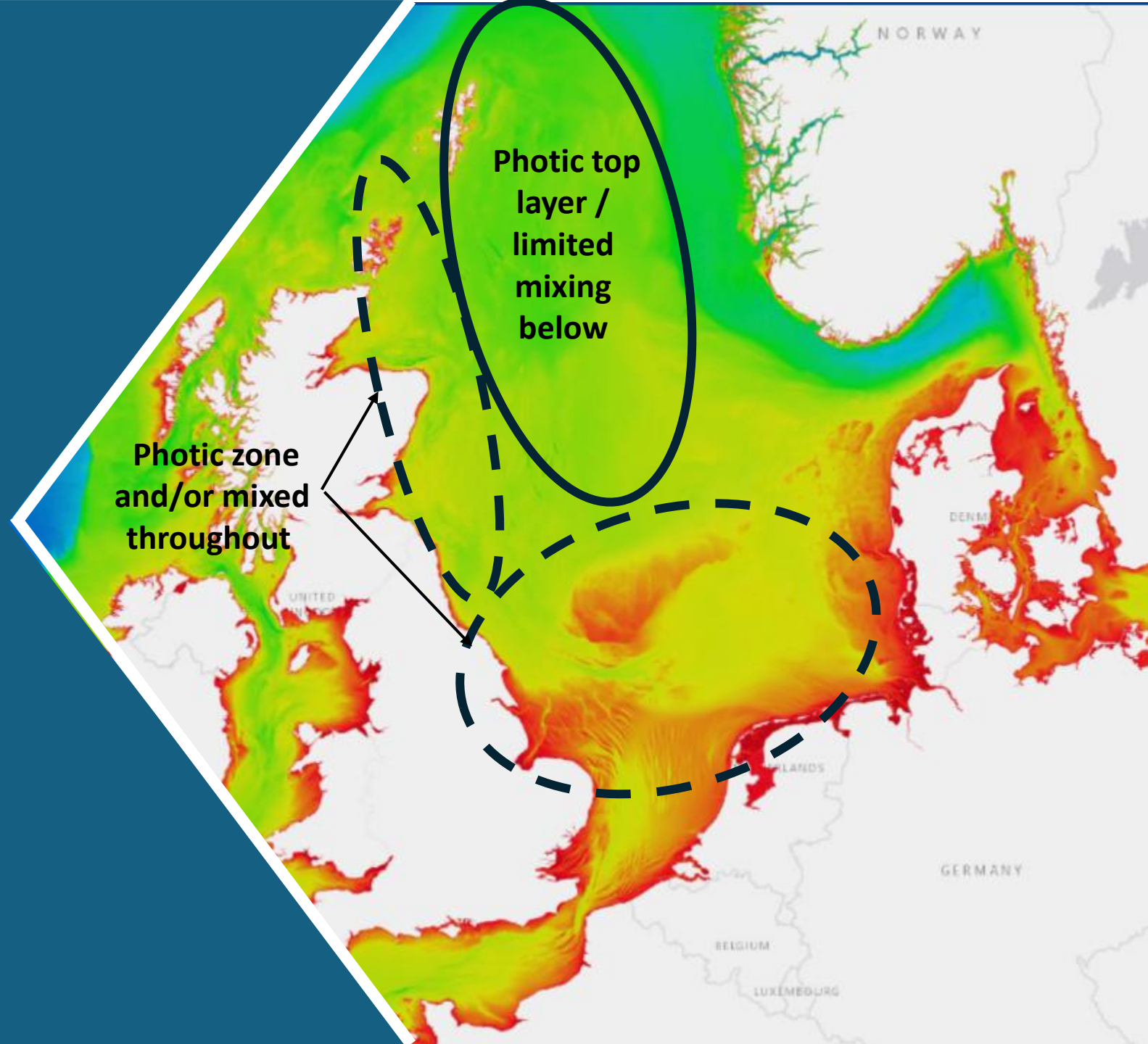
The Productive 'Marine Mainland'

Photosynthesis

Sunlight + CO₂ + Water
→ Glucose + Oxygen

Productivity of an ecosystem

Efficiency of plants and other producers to capture energy (usually from sunlight) and transform it into biomass that supports the rest of the food web.



O&G Installations

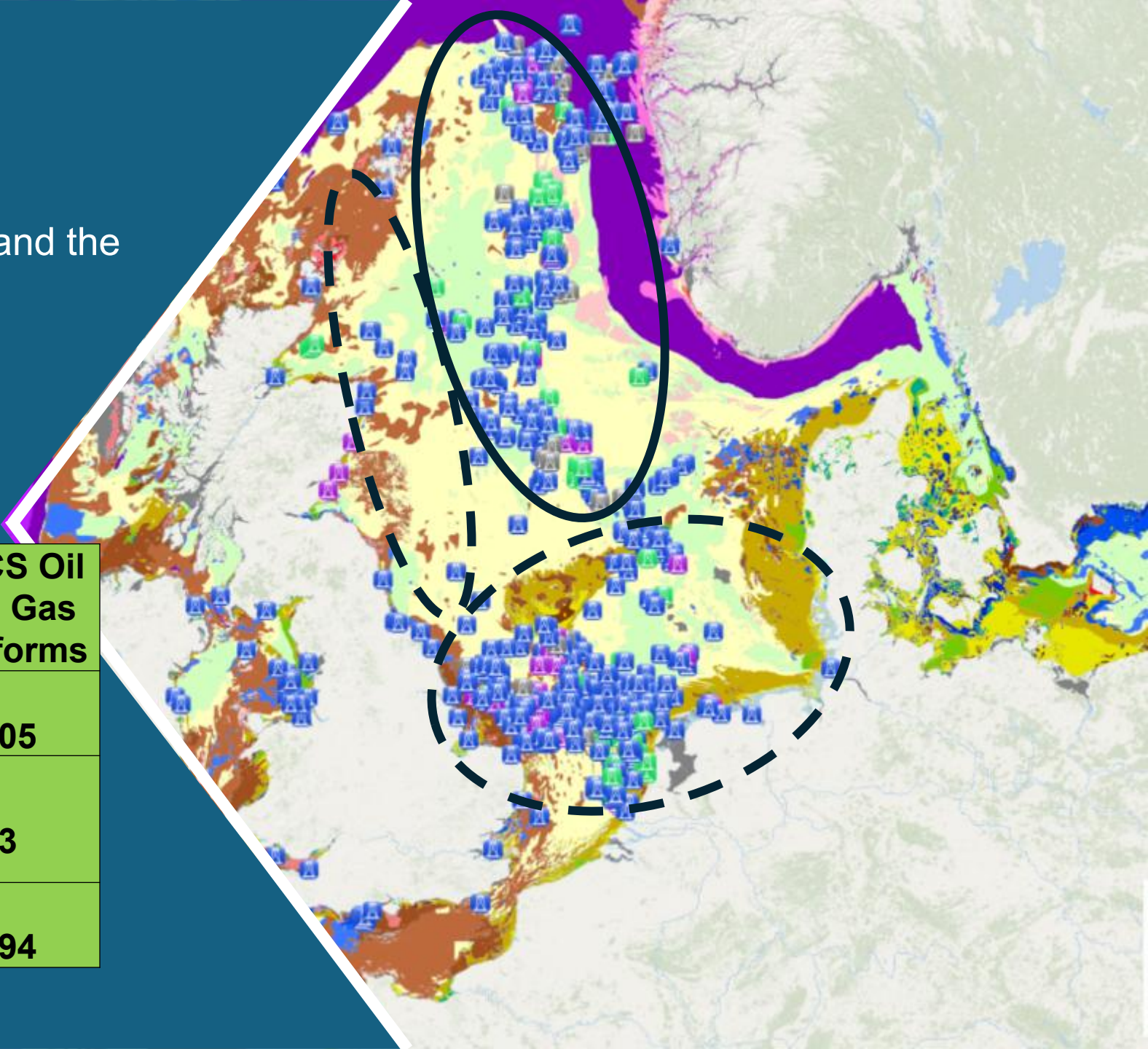
CNS, NNS, WoS

Small islands, isolated from each other and the productive ‘mainland’

SNS

Small islands, connected, in the productive ‘mainland’

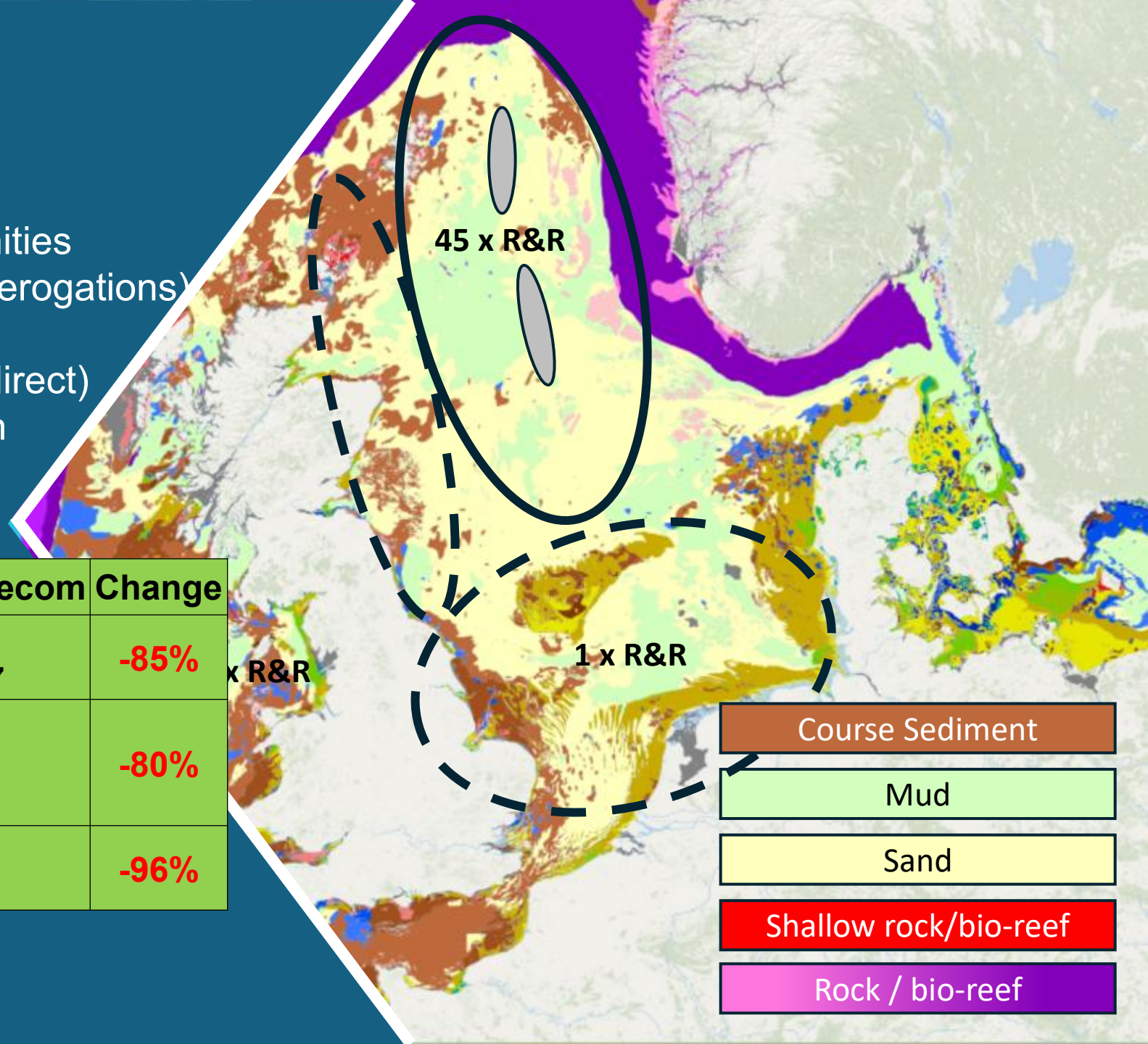
	Measure	UKCS Oil and Gas Platforms
Number of Communities	Installations	305
Hard Substrate Surface Area	km ² of submerged structure	3
Area Protected	km ² safety zone	194



O&G Remains and Residues

- Complete destruction of 294 communities
- Major alteration to 36 communities (derogations)
- 11 communities remain intact (GBS)
- 240,000 tonnes of marine life killed (direct)
- Cost of substructure removal = ~£3bn

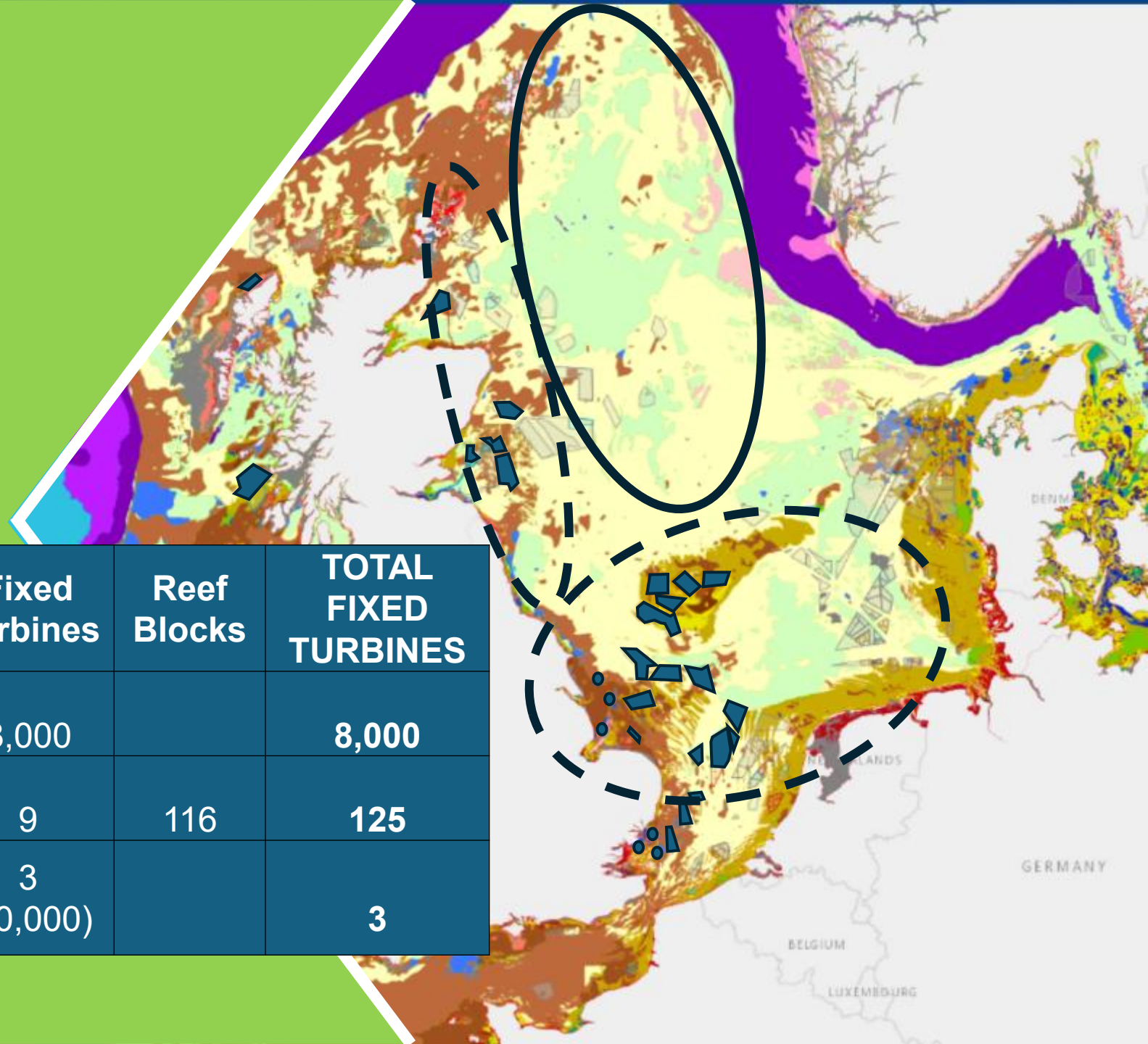
	Measure	Post Decom	Change
Number of Communities	Installations	47	-85%
Hard Substrate Surface Area	km ² of submerged structure	1	-80%
Area Protected	km ² safety zone	8	-96%



Fixed Bottom Windfarms

- Small islands (50m radius safety zones)
- Semi protected from fishing (polygons)
- Located in the productive 'mainland'
- Well connected
 - Turbine to turbine
 - Windfarm to windfarm

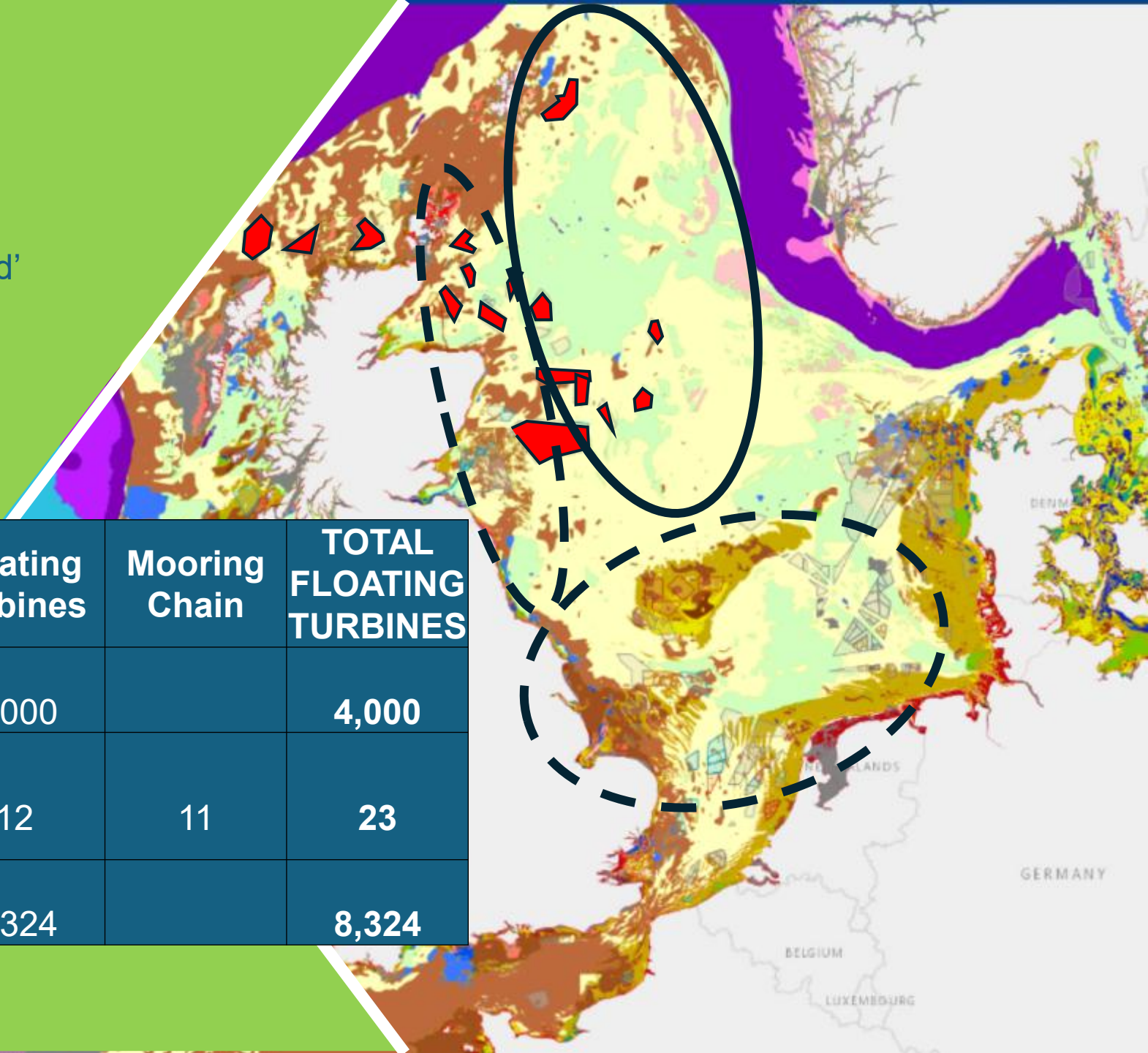
	Measure	Fixed Turbines	Reef Blocks	TOTAL FIXED TURBINES
Number of Communities	Installations	8,000		8,000
Hard Substrate Surface Area	km ² of submerged structure	9	116	125
Area Protected	km ² safety zone (50m ² / (polygon)	3 (20,000)		3



Floating Windfarms

- Located close to the productive 'mainland'
- Large islands of protection from fishing
- Well connected
 - Turbine to turbine
 - Windfarm to windfarm

	Measure	Floating Turbines	Mooring Chain	TOTAL FLOATING TURBINES
Number of Communities	Installations	4,000		4,000
Hard Substrate Surface Area	km ² of submerged structure	12	11	23
Area Protected	km ² safety zone	8,324		8,324



What does 2060+ Look Like?

£3
Bn

Cost of substructure removal

294
36
11

Communities
(destroyed, changed, left)

240
K

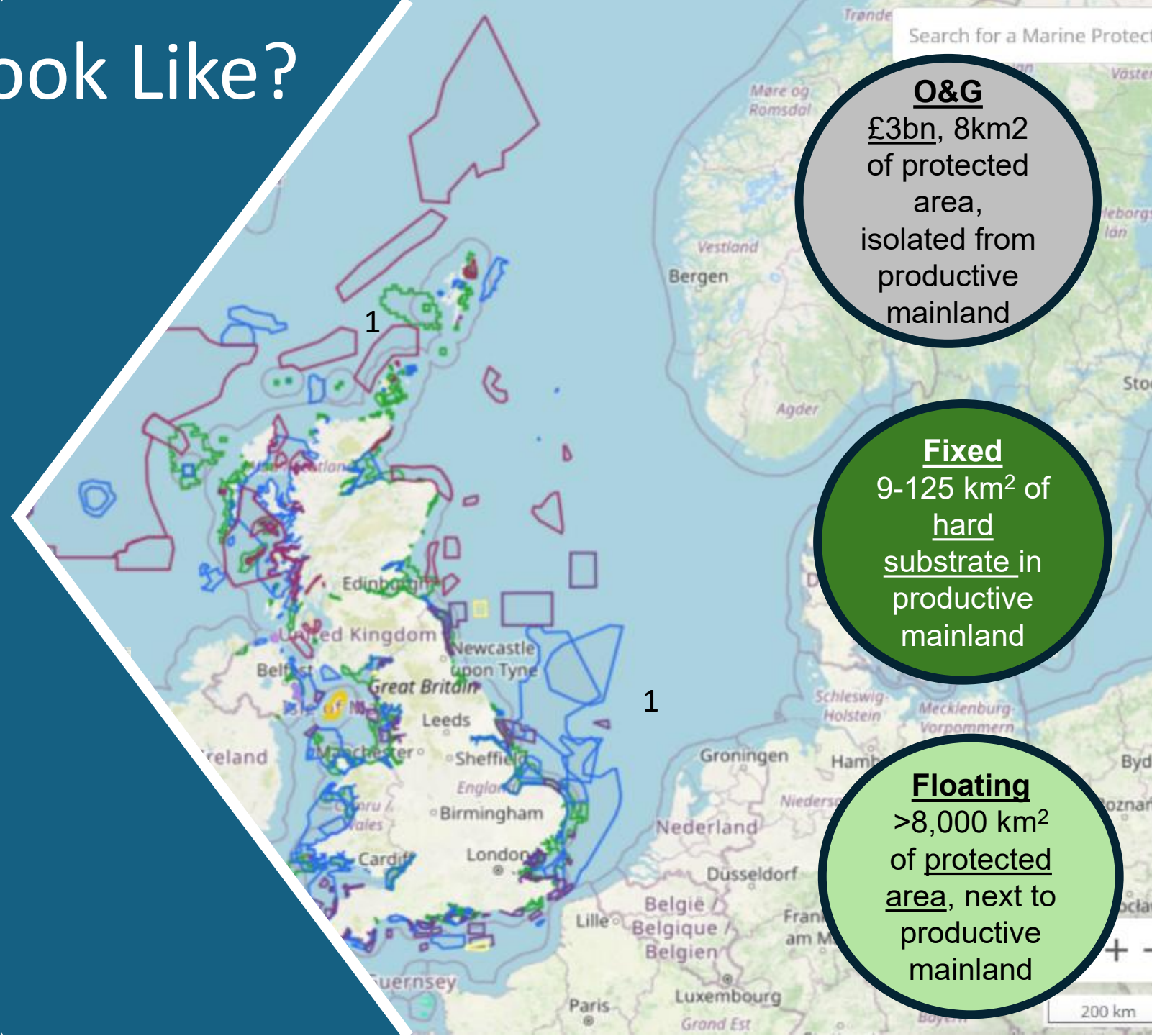
Tonnes of marine life killed



Connectivity (minor)

237
km

Seabed returned to fishing





THANK YOU

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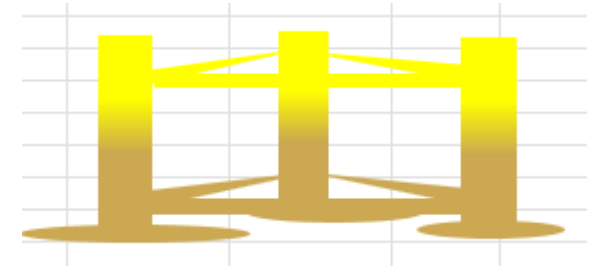
Workings

Offshore Wind Surface Area

[illegible]

102mm chain moorings		
Surface area per link		
Length per mooring	1 km	
Per turbine	3 km	
Surface area per turbine	527000 mm ²	122mm
Surface area per turbine	0.527 m ²	
Surface area per turbine	5.27E-07 km ²	
	567 mm	
	0.00057 km	
Chains per KM	1764 Links	
Surface Area per KM	0.00 km ²	
3 chains per structure	0.00 km ²	
SA of chain all structures	11 km ²	

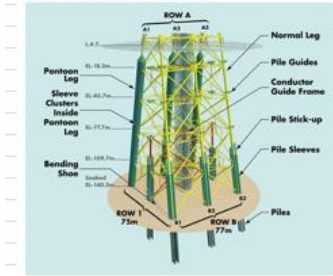
A diagram of a chain link, which is an oval shape. The horizontal width is labeled as 408mm with a double-headed arrow. The vertical height is labeled as 122mm with a single-headed arrow pointing to the right side of the oval.



Offshore Oil and Gas Surface Area

[illegible]

Figure 28 The Main Components of the Brent Alpha Platform.



BRENT FIELD DECOMMISSIONING PROGRAMMES

Figure 31. Condition of the Brent Alpha Footings after Removal of the Upper Jacket.

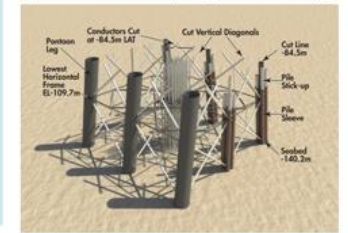
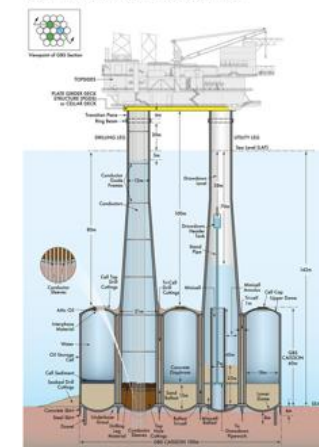
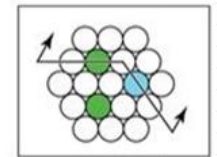
BRENT FIELD DECOMMISSIONING PROGRAMMES
DECOMMISSIONING THE BRENT FACILITIES

Figure 44. The Main Structural Features of the Condeep OBS Benthic Bows



Radius (r)

500

Diameter (d)

1,000

Area (A)

785,398

Circle area = $\pi \times r^2 = \pi \times 250,000 \text{ m}^2 = 785,398 \text{ m}^2$

$\pi = 3.14159265 \approx 3.14$

$d = r \times 2 = 500 \text{ m} \times 2 = 1,000 \text{ m}$

Offshore Oil and Gas left in situ – Richard Stark PhD

	0 - 1999 tonnes	2000 - 9,999 tonnes	10,000 tonnes +											
Data Source	OSPAR(2021)	OSPAR(2021)	OSPAR(2021)	OSPAR(2021)	OSPAR(2021)	OSPAR(2021)	OSPAR(2021)	OSPAR(2021)	OSPAR(2021)	NSTA (2022)		OSPAR(2019)	NSTA(2022)	(Shell 2017. Pg 119)
	Small steel	Large Steel (incl Maureen)	Ultra-large steel	CGBS	GBS Topside	Platform Topsides	Floating	Subsea Structures	Pipelines	TOTAL		Drill Cutting Piles	Abandoned Wells	Marine Life
Norway	9	42	7	9						67				
Number of structures (UK)	187	71	36	11	11	305	52	516	1305	2,494		1,150,086 m³	8,000 wells	294 communities
The Netherlands	125	7	2	1						135 54 2				
Denmark	46	7	0	1										
Germany	1	0	1	0										
TOTAL	368	127	46	22		305	52	516	1305			0	0	
OSPAR INVENTORY 2015 (Fixed Structures)														
Seabed Footprint (km²)/ % of North Sea Note 11)	145km² / 0.03%	55km² / 0.009%	28km² / 0.004%	9km² / 0.001%			41km² / 0.007%			278km² / 0.04%				
	Full Removal	Full Removal	Partial Removal	Leave in situ	Full Remove	Full Removal	Full Removal	Full Removal	Full or partial removal			Leave in situ	Leave in situ	Partial removal
Country	Small steel	Large Steel (incl Maureen)	Ultra-large steel	Concrete		Platform Topsides	Floating	Subsea Structures	Pipelines	TOTAL		Pipelines	Pipelines	
Norway														
Weight of Structures (UK) (Tonnes)	161,893	367,224	731,593	2,742,781	225,595	1,721,176	1,871,539	73,693	1,132,668	9,028,162				239,535
The Netherlands										-				
Denmark										-				
Germany										-				
TOTAL (tonnes)	161,893	367,224	731,593	2,742,781	225,595	1,721,176	1,871,539	73,693	1,132,668	9,028,162				
% of all structural weight	2%	4%	8%	30%	2%	19%	21%	1%	13%					
Approximate % left in situ	0%	0%	66%	100%	0%	0%	0%	0%	50%					
	Note 1	Note 1	Note 2	Note 3	Note 4	Note 4	Note 5	Note 6	Note 7			Note 8	Note 9	Note 10
Total Weight left-in-situ (Tonnes)	0	0	482,851	2,742,781	0	0	0	0	566,334	3,791,966		1,150,086 m3	8,000 wells	
% of total weight installed left in situ	0%	0%	5%	30%	0%	0%	0%	0%	6%	42%				
Duration of Residual Liability (Note 12)	0 years	0 years	100 - 200 years	500 - 1000 years	0 years	0 years	0 years	0 years	100 - 200 years			100 years	Perpetuity	

Reef Blocks at Rampion Windfarm and UKCS

EDF Rampion installed 88,000 reef blocks at Rampion where there is 116 turbines https://eeegr.com/2025/07/24/arc-marine-works-with-rwe-rampion-offshore-wind-farm-to-create-artificial-reef/									
Cubes between 15-35cm (av 20cm)	20	x	20	x	6	2400	cm2	equals	0.24 m2
Surface area therefore equals	88,000	x	0.24		21,120	m2			
No of blocks at Rampion	88,000	x	116		10,208,000	blocks at Rampion			
Surface area at Rampion	10,208,000	x	0.24		2,449,920	m2 of surface area at Rampion			
Weight installed at Rampion	10,208,000	x	470		4,797,760,000	kg		equals	4,797,760 tonnes
Surface area installed 2026-2050	21,120	x	5,500		116,160,000	m2		equals	116 km2
currently blocks have a certified 99 year lifespan - looking 1000! https://www.rivieramm.com/news-content-hub/news-content-hub/pilot-project-tests-more-sustainable-alternative-to-conventional-scour-protection-85727									
5,500	Fixed bottom turbines installed 2026 - 2050								
116	Turbines	At Rampion							
88000	Blocks	Installaed at one Rampion Turbine							
2350	kg/m3	density of a 1m2 block							
470	kg	density of a 20cm3 block at Rampion							



Offshore Wind operating and Planned - Offshorewindscotland

Wind Farm	Turbine	Foundation Type	Region	Water Depth (m)	Capacity (MW)	Start Year	In 2017 Arup Decom Rep
Barrow	30	Monopile	England	15–20	90	2006	Yes
Blyth Demo Phase 1	5	Floating & Gravity	England	35–45	42	2017	Yes
Burbo Bank	25	Monopile	England	5–10	90	2007	Yes
Burbo Bank Extension	32	Monopile	England	5–10	258	2017	Yes
Dudgeon	67	Monopile	England	18–25	402	2017	Yes
East Anglia One	102	Monopile	England	30–40	714	2020	Yes
Galloper	56	Monopile	England	25–35	353	2018	Yes
Greater Gabbard	140	Monopile	England	25–35	504	2012	Yes
Gunfleet Sands	48	Monopile	England	5–10	172	2010	Yes
Humber Gateway	73	Monopile	England	15–20	219	2015	Yes
Kentish Flats	30	Monopile	England	5–10	90	2005	Yes
Kentish Flats Ext.	15	Monopile	England	5–10	50	2015	Yes
London Array	175	Monopile	England	5–20	630	2013	Yes
Lynn & Inner Dowsing	54	Monopile	England	10–15	194	2009	Yes
Lincs	75	Monopile	England	10–15	270	2013	Yes
Ormonde	30	Jacket	England	20–30	150	2012	Yes
Rampion	116	Monopile	England	20–30	400	2018	Yes
Scroby Sands	30	Monopile	England	5–10	60	2004	Yes
Sheringham Shoal	88	Monopile	England	15–20	317	2012	Yes
Teesside	27	Monopile	England	10–15	62	2013	Yes
Thanet	100	Monopile	England	20–25	300	2010	Yes
Walney Phase 1 & 2	102	Monopile	England	20–25	367	2011	Yes
Walney Extension	87	Monopile	England	20–25	659	2018	Yes
West of Duddon Sands	108	Monopile	England	20–25	389	2014	Yes
Westermorst Rough	35	Monopile	England	20–25	210	2015	Yes
Hornsea One	174	Monopile	England	25–35	1218	2020	Yes
Robin Rigg	60	Monopile	Scotland	10–15	180	2010	Yes
Dogger Bank A	95	Monopile	England	25–35	1200	2023	No
Dogger Bank B	95	Monopile	England	25–35	1200	2024	No
Dogger Bank C	87	Monopile	England	25–35	1200	2025	No
Triton Knoll	90	Monopile	England	20–30	857	2022	No
Hornsea Two	165	Monopile	England	25–35	1386	2022	No
Aberdeen Bay	11	Jacket	Scotland	20–30	93	2018	No
Beatrice	84	Jacket	Scotland	40–45	588	2018	No
Hywind Scotland	5	Floating	Scotland	95–120	30	2017	No
Moray East	100	Jacket	Scotland	35–45	950	2022	No
Seagreen	114	Jacket	Scotland	40–55	1075	2023	No
Nearrt na Gaoithe	54	Jacket	Scotland	40–55	450	2025	No
Gwynt y Môr	160	Monopile	Wales	12–20	576	2015	No
North Hoyle	30	Monopile	Wales	10–15	60	2003	No
Rhyl Flats	25	Monopile	Wales	5–10	90	2009	No
Kincardine	5	Floating	Scotland		48		

FLOATING- SCOTLAND					
SITE					CAPACITY (MW)
Pentland					100
Muir Mhor					1,000
Ossian					3,610
Buchan					960
Bellrock					1,800
CampionWind					3,000
Ayre					1,008
Stromar					1,500
Broadshore					900
MarramWind					3,000
Hevbredey					1,500
Talisk					495
Arwen					2,300
Stoura					500
Green Volt (INTOG)					560
Culzean Demo (INTOG)					3
Salamander (INTOG)					100
Cenos (INTOG)					1,350
Aspen (INTOG)					1,008
Sinclair					100
Scaraben					100
Flora					50
Malin Sea Wind					100
Aspen 2					1,008
Beech					1,008
Cedar					1,008
HE Project					15
Total					28,083

<https://www.offshorewindscotland.org.uk/the-offshore-wind-market-in-scotland/floating-wind-in-scotland/#:~:text=Scotland%20is%20a%20world%20leader,be%20found%20in%20this%20section.>

UK Govt Offshore Windfarms

[illegible]

EMOD Net UK Offshore Windfams

[illegible]

Offshore Wind decom costs – via ORE Catapult

			1000	Per kW	£ 86	£ 130	£ 69	£ 285
	2050 MW	2050 kW			Turbine	Foundation	Cables	Subsea Remediation
Offshore Wind (Low end of estimate) GW		115	115,000					
Fixed		32,700	32,700,300		£ 2,812,225,800	£ 4,251,039,000	£ 2,256,320,700	£ 9,319,585,500
Floating - Tow of substructure = barging of jacket	28,719		28,719,000		£ 2,469,834,000		£ 1,981,611,000	£ 4,451,445,000
TOTAL DECOM COST					£ 5,282,059,800	£ 4,251,039,000	£ 4,237,931,700	£ 13,771,030,500

	KW	£	£	£	£	£
Windfarms included in Arup 2017 Report	9,141,100	786,134,600	1,188,343,000	630,735,900	-	2,605,213,500
Operating windfarms in 2025 not in 2017 Report	9,051,200	778,403,200	1,176,656,000	624,532,800	-	2,579,592,000
Planned windfarms @ 2025 (not in Arup Report)	14,508,000	1,247,688,000	1,886,040,000	1,001,052,000	-	4,134,780,000
Floating Windfarms	28083	28,719,000	2,469,834,000	3,733,470,000	1,981,611,000	-
						£ 9,319,585,500

https://cms.ore.catapult.org.uk/wp-content/uploads/2021/04/End-of-Life-decision-planning-in-offshore-wind_FINAL_AS-1.pdf

Table 1 Cost of UK offshore wind farm (400MW) decommissioning (installed in monopile foundations and excluding weather downtime)

Component	DECEX (£/kW)	Vessel type	Time (hours/turbine)
Turbine	86	Large jack-up	36
Foundation	130	Large jack-up/feeder barge	24
Array cable	69	Cable-laying vessel	72
Total	285	#	132