MARATHON BRAE

Brae Alpha, Brae Bravo, Central Brae, West Brae and Sedgwick Combined Decommissioning Programmes Environmental Statement: Technical Appendices

June 2017 Consultation Draft

Marathon Oil

9000-MIP-99-EV-RT-00001-001, I02

Consultation Draft

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Document Control

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Revision Control

Revision No	Reference	Changes/Comments	Issue Date
0	Draft	Draft issue for client review	Feb 2017
1	Draft	Client Review	March 2017
2	Issued	Consultation Draft	June 2017

Distribution List

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Terms and Abbreviations

AE	Accidental Event
APE	Alkylphenol Ethoxylates
BAT	Best Available Technique
BEIS	Department of Business Energy and Industrial Strategy (UK Government)
BEP	Best Environmental Practice
CA	Comparative Assessment
CITES	Convention on International Trade of Endangered Species of wild fauna and flora
CO_2	Carbon Dioxide
DP	Decommissioning Programme
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
ES	Environmental Statement
ERL	Effects Range Low - value is the lower tenth percentile of the data set.
ERM	Effects Range Median
EUNIS	European Nature Information System
EWC	European Waste Code
FPV	Fall Pipe Vessel
ICES	International Council for the Exploration of the Sea
IUCN	International Union for Conservation of Nature
JNCC	Joint Nature Conservation Committee
LAT	Lowest Astronomical Tide
LOI	Loss on Ignition
MDAC	Methane-Derived Authigenic Carbonates
MMO	Marine Mammal Observer
NEBA	Net Environmental Benefits Analysis
OPEP	Oil Pollution Emergency Plan
OSPAR	"OS" for Oslo and "PAR" for Paris Convention
PAH	Polycyclic Aromatic Hydrocarbon
PAM	Passive Acoustic Monitoring
PCB	Polychlorinated Biphenyls

PMF	Priority Marine Feature
PONs	Petroleum Operations Notices
PTS	Permanent Threshold Shift
RMS SPL	Root Mean Square Sound Pressure Level
SAC	Special Area of Conservation
SD	Seabed disturbance
SEL	Sound Exposure Level
SEPA	Scottish Environment Protection Agency
SFF	Scottish Fishermen's Federation
SNH	Scottish Natural Heritage
SPL	Sound Pressure Level
SR	Scoping Report
ROV	Remote Operated Vehicle
TBT	Tributyltin
THC	Total Hydrocarbon Concentration
TTS	Temporary Threshold Shift
UKBAP	United Kingdom Biodiversity Action Plan
UKCS	United Kingdom Continental Shelf
UN	Underwater Noise

Technical Appendix: 2.1: Scoping Consultation Register

The scoping report was submitted to DECC (now BEIS), JNCC, Marine Scotland and SEPA in February 2016. This technical appendix provides a summary of the key points raised by stakeholders in response to the EIA Scoping Report.

Table TA2.1.1: EIA Scoping Consultation Responses

Consultee	Comments Received	Response to Comments
Marine Scotland (response dated 15.3.16)	Scoping Methodology Section 4.1 and 4.2 of the EIA Scoping Report makes reference to Annex B and Annex D1 but it is not clear how these Annexes have been used to inform the Scoping Process.	Annex B provides the detailed methodology which was applied and was the basis for allocating categories to the likely effects (i.e. High, Medium, Low, Negligible or No Impact) during the Preliminary Scoping Process. Annex D1 provides the detailed methodology which was applied to the detailed scoping process (stage 2).
	Scoping Methodology There are no areal extents given for the three categories in Annex D for the descriptors local, regional or national/international.	Within the EIA Scoping process, the following extents were considered: • Local: <10 km^2 • Regional: <200 km^2 • National/International: >200 km^2
	Non-Significant Issues Where receptors are being scoped out it was suggested that more evidence is provided to justify the decision e.g. Table D.2 in section D2.1 requires more detail such as quantifying the footprint of the activity in order to provide a better understanding of the scale and context of the activity/receptor interaction.	Noted. Further detail on issues scoped out is provided in Technical Appendix 4.1: Scoping Rationale.
SEPA (response dated 15.3.16)	Scoping Methodology Within the definitions of event categories, some indication of the type of environmental effect or unacceptable risk considered would be of value.	Noted. No further revisions to the Scoping Report are proposed, however the methodology section within the relevant Technical Appendices to the ES will provide some examples of typical high/medium/low magnitude and sensitivity criteria (where relevant).
	Scoping Methodology Within Table B.1, under 'likelihood of accidental event' (2nd column) it is unclear as to where the frequencies of release have been derived. Are these estimates, as in Table 4.1, derived using professional judgement or are they derived from industry standards / knowledge? Given that the decommissioning industry is in its	The frequencies referenced within Table B.1 were derived through application of professional judgement as well as industry specific knowledge provided by Marathon Oil. It is considered that the frequencies referenced are appropriate for the decommissioning activities and form a valid basis for the EIA Scoping process. The assessment of accidental events (in Chapter 5: Summary of Environmental Effects) is informed by the analysis of historic data on hydrocarbon

Table TA2.1.1: EIA Scoping Consultation Responses

Consultee	Comments Received	Response to Comments
	infancy it is assumed that the former is the case. Could failure / accident/ release frequencies derived for on-shore oil and gas be utilised for this screening aspect?	and chemical spills collected by BEIS (formerly DECC) through the Petroleum Operations Notices (PONs) system. Appropriate reference is also be made to the Brae Area Oil Pollution Emergency Plans (OPEPs).
	Scoping Methodology Detailed scoping using sensitivity, duration and geographical extent. It is not immediately clear how each of these parameters have been used to scope in /out an activity or impact. Some additional discussion would be of value. Where one or more parameters do not apply it may be beneficial to indicate this in Table D.2.	Noted. The rationale for scoping decisions is set out in Annex D2 of the Scoping Report.
	Assessment Methodology As ' Significant environmental effect' is defined as those activity/receptor interactions assigned a category of Medium or High, then within Table 4.1 the category definitions for 'Low', 'Negligible' and 'No Impact/Positive' can be amended by removal of 'significant' from each definition.	Noted
	Assessment Methodology Further clarification should be given on the definition of 'significant' and 'small' with regard to loss of an environmental feature (see descriptions for Medium and Small Magnitudes).	The use of the term significant and small in the description for medium/small magnitude is not considered essential to the meaning of the description, the key element of the description is the potential risk to the integrity and/or functionality of that feature. To clarify and assist the reader, the descriptions should read as follows: •Medium Magnitude: If an identified impact would result in loss of a proportion of an environmental feature with potential risk to integrity and/or functionality of that feature; result in regional concerns from stakeholders. •Small Magnitude: If an identified impact would result in loss of parts of an environmental feature, not affecting integrity and/or functionality; result in local concerns from stakeholders.
	Similarly, a definition of what represents 'long term' when applied to improvement of an environmental feature / ecosystem service and its functionality is required.	•The term long-term, when applied to the improvement of an environmental feature/ecosystem service and its functionality, is considered to apply when the improvement is

Table TA2.1.1: EIA Scoping Consultation Responses

Consultee	Comments Received	Response to Comments
		anticipated to be sustained for a period of more than 10 years.
	Environmental Baseline This section may have benefited from the inclusion of a number of figures and/or maps detailing the location of receptors relative to the project area e.g. spawning grounds, designations (pockmarks).	Noted. Figure and Maps (as appropriate) are provided in the ES.
JNCC (response dated 15.3.16)	Scope of the EIA Pleased to see that potential effects of decommissioning activities on the Braemar Pockmarks Special Area of Conservation (SAC) will be given due consideration within the EIA.	Noted
	Scope of the EIA Query the Medium-Low classification of 'Seabed Disturbance Effects (marine benthos, geology, natural seabed sediment and drill cuttings pile) during jacket removal (possibly including footings), and removal of subsea infrastructure. It is considered that the removal of the jacket footings (which may involve disturbing the cuttings piles) would result in a seabed impact through direct and indirect disturbance, including the possible suspension of contaminated cuttings, and therefore should be considered in the 'Medium / High' category.	The effect of seabed disturbance as a result of jacket removal, and removal of subsea infrastructure has been addressed in ES Chapter 5: Summary of Environmental Effects. It is noted that the potential for significant effects associated with the disturbance of the drill cuttings piles has been scoped out on the basis that the DP proposes to leave the jackets in place. The jacket/sub-structure will be cut above the footings (as described in the DP) and therefore avoid the potential suspension of contaminated cuttings.
	Scope of the EIA Query the No Impact- Low classification of 'Seabed Disturbance Effects…' during the leaving in-situ of pipelines/umbilicals/cables/flowlines. Although this will be a localised effect, it is considered that the addition of rock into a soft-sediment habitat is causing a permanent change to the environment, and considering the amount of pipelines (etc.) there are in the Brae area, the potential for a larger-scale addition of protective rock means there may be some cumulative impacts which should be considered. It is therefore considered that this classification is revisited.	The effect of seabed disturbance as a result of rock placements on pipelines/umbilicals/cables/ flowlines has been assessed, with the summary of seabed disturbance presented in ES Chapter 5: Summary of Environmental Effects, supported by Technical Appendix 5.2: Seabed Disturbance.

Table TA2.1.1: EIA Scoping Consultation Responses

Consultee	Comments Received	Response to Comments
	Scope of the EIA Further information should be provided on the further pre-decommissioning survey to check for the presence of designated species referenced on Page 83 (Table D3).	Further details on the proposed pre-decommissioning checks is provided in ES Chapter 5: Summary of Environmental Effects.

Technical Appendix 3.1: Brae Area Environmental Baseline Data Seabed Sediment Chemical Data

This technical appendix provides a summary of sediment chemical characteristics.

Table TA3.1.1 Brae Area Environmental Baseline Data: Seabed Sediment Chemical Data

Sample station	Closest Platform	Distance / orientation from closest platform	THC (µgg-1 dry sediment)	Total n-Alkanes (µgg^{-1} dry sediment)	Total PAHs (µgg^{-1} dry sediment)[1]	Metal Concentrations (µgg^{-1})[2]																Survey Ref and Date
						Al	Ar	Ba	Total Ba	Cd	Cr	Ni	V	Cu	Fe	Pb	Zn	Hg	Li	Sn	Total PCBs	
8	Alpha	3500m SW	Not available (Na)	0.348	0.075	Not available (Na)	Na	9.67	Na	0.51	11.68	6.54	10.83	2.22	5517	15.09	15.45	Na	Na	Na	Na	IOE, 1981
9	Alpha	3300m 180°	Na	0.266	0.09	Na	Na	98.2	Na	0.81	12.13	7.14	10.37	2.13	5442	14.52	15.77	Na	Na	Na	Na	IOE, 1981
1	Alpha	3500m 300°	Na	0.307	0.075	Na	Na	53.95	Na	0.51	9.09	3.98	9.49	1.44	4303	10.33	8.32	Na	Na	Na	Na	BRA81
3	Alpha	3000m 45 °	Na	0.263	0.0197	Na	Na	190	Na	0.46	8	4.27	8.63	1.07	4006	10.86	11	Na	Na	Na	Na	BRA81
8	Alpha	3400m 225 °	Na	0.348	0.075	Na	Na	96.7	Na	0.51	11.68	6.54	10.83	2.22	5517	15.09	15.45	Na	Na	Na	Na	BRA81
9	Alpha	3033 180 °	Na	0.266	0.089	Na	Na	98.2	Na	0.81	12.13	7.14	10.37	2.13	5442	14.52	15.77	Na	Na	Na	Na	BRA81
Ref 1	East Brae	19000m 256 °	Na	0.2	0.1297	Na	Na	74.3	Na	Not detected (ND)	4.7	Na	Na	ND	Na	ND	10	<0.05	Na	Na	Na	Auris 1991/1992 [3]
Ref 2	East Brae	16000m 252 °	Na	0.242	0.107	Na	Na	88.3	Na	ND	2.3	Na	Na	2	Na	ND	7.7	<0.05	Na	Na	Na	Auris 1991/1992
N250	East Brae	250m 0 °	Na	0.267	0.2115	Na	Na	645.3	Na	ND	6.3	Na	Na	1	Na	ND	12.7	<0.05	Na	Na	Na	Auris 1991/1992
S250	East Brae	250m 180 °	Na	0.307	0.1287	Na	Na	271.3	Na	ND	9	Na	Na	3	Na	ND	16.3	<0.05	Na	Na	Na	Auris 1991/1992
A2	Brae Alpha	3050m 0 °	Na	0.263		Na	Na	428	Na	<0.01	10	5	8	6	6680	9	12	0.09	Na	Na	Na	ERT 2000
XA2	Brae Alpha	3000m 0 °	9.7	0.556	Na	Na	Na	340	Na	<0.01	12	6	10	6	7560	11	14	<0.01	Na	Na	Na	ERT 2000
XB2	Brae Bravo	3000m 135 °	3.6	0.194	Na	Na	Na	221	Na	<0.01	9	4	7	6	6080	8	9	<0.01	Na	Na	Na	ERT 2000
E1	East Brae	5000m 0 °	3.6	0.155	Na	Na	Na	162	Na	<0.01	15	8	13	5	7800	10	20	<0.01	Na	Na	Na	ERT 2000
WA02	Brae Bravo	10752m 80 °	2.5	0.127	0.052	1640	1.79	99.4	196	0.02	7.57	3.80	6.77	1.58	Na	4.64	9.59	<0.03	<0.15	<3	Na	Fugro 2013(1)

Table TA3.1.1 Brae Area Environmental Baseline Data: Seabed Sediment Chemical Data

Sample station	Closest Platform	Distance / orientation from closest platform	THC (µgg-1 dry sediment)	Total n-Alkanes (µgg^{-1} dry sediment)	Total PAHs (µgg^{-1} dry sediment)[1]	Metal Concentrations (µgg^{-1})[2]																
						Al	Ar	Ba	Total Ba	Cd	Cr	Ni	V	Cu	Fe	Pb	Zn	Hg	Li	Sn	Total PCBs	Survey Ref and Date
WA03	Brae Bravo	10276m 285°	2.4	0.139	0.041	1640	1.60	63.4	243	0.01	6.81	3.64	9.13	1.49	Na	4.94	9.29	<0.03	<0.15	<3	Na	Fugro 2013(1)
WA04	Brae Bravo	7232m 306°	2.1	0.147	0.075	2810	1.96	140	296	0.03	10.8	6.91	7.13	2.62	Na	5.96	14.7	<0.03	<0.15	<3	Na	Fugro 2013(1)
WA05	Brae Bravo	16436m 194°	3.4	0.14	0.055	1630	2.30	153	255	0.02	8.00	3.70	7.13	1.60	Na	5.11	10.1	<0.03	<0.15	<3	Na	Fugro 2013(1)
MB01	Brae Bravo	5000m 0°	1.7	0.099	0.028	1430	1.65	58.1	262	0.01	6.46	3.19	5.93	1.29	Na	4.48	7.46	<0.03	<0.15	<3	Na	Fugro 2013(1)
MB08	Brae Bravo	5000m 180°	2.7	0.117	0.038	1190	2.11	82.1	85	0.01	6.62	2.60	6.00	1.15	Na	4.86	7.30	<0.03	<0.15	<3	Na	Fugro 2013(1)
BA06	Brae Alpha	3118m 0°	8.1	0.28	0.13	7460	5.56	1780	330	0.07	27.8	19.0	28.7	7.50	Na	15.3	37.9	<0.04	<0.30	0.50	Na	Fugro 2015(1)
BA12	Brae Alpha	5000m 180°	4.9	0.24	0.128	6750	4.30	539	397	0.05	25.1	17.5	24.2	5.92	Na	11.8	31.7	<0.04	<0.30	0.29	Na	Fugro 2015(1)
Minimum			1.7		0.0197	1190	1.6	53.95	85	0.01	2.3	2.6	5.93	1	4006	4.48	7.3	Below method detection limits	Below method detection limits	0.29		
Maximum			9.7		0.2115	7460	5.56	1780	397	0.81	27.8	19	28.7	7.5	5517	15.3	37.9			0.5		

Notes:

[1] For BRA81 samples, Total PAH has been calculated by summing values for phenanthrene, and 4, 5 and 6-ring PAHs provided in UKBenthos database.

[2] Mean metal concentrations from IOE, 1981 have been used.

[3] For Auris 1991/1992, the nitric acid extractable metal concentrations (AEX) were used rather than the total concentrations (TOT) as this more accurately reflects the sample preparation used in other studies. The report provides three results per sample location – these have been averaged in the table above. The exception is mercury, as this was only reported as total. Also, for n-Alkanes the average of the values reported for C12-33 has been used.

Technical Appendix 3.2: Brae Area Environmental Baseline Data: Fisheries

This technical appendix provides a summary of the catch by landings (quantity and value) for ICES rectangle (46F1) and the catch per unit effort from the ICES rectangle (46F1).

Catch by Landings (Quantity and Value) for ICES rectangle; 46F1

A breakdown of the landings (quantity and value) from the ICES rectangle 46F1 by UK vessels into the UK and abroad and by foreign vessels into the UK, is provided in Table TA3.2.1. Most vessels that actively fished in the study area in the period 2009 to 2014 were registered within the UK [3]. Therefore, whilst no information was obtained on landings from the ICES rectangle 46F1 at foreign ports from non-UK vessels, these are expected to be limited. It is acknowledged however that the data below may be an underestimation of the real commercial value from the area.

Table TA3.2.1: Breakdown of average annual value (real 2014 GBP) and liveweight (tonnes) for all species landed from the ICES rectangle 46F1 during 2009 – 2014 [4]

	Value (real 2014 GBP)	Percentage of total value (%)	Liveweight (tonnes)	Percentage of total liveweight (%)
Nephrops[1] (Norway lobster)	£682,769.97	49.3%	204	15.6%
Herring[2]	£252,485.90	18.2%	690	52.7%
Monks or Anglers[1]	£97,384.58	7.0%	28	2.1%
Horse mackerel[3]	£77,514.63	5.6%	177	13.5%
Haddock[1]	£75,493.68	5.4%	74	5.6%
Cod[1]	£49,143.78	3.5%	23	1.7%.
Hake[1]	£35,717.26	2.6%	24	1.8%
Whiting[1]	£32,166.05	2.3%	32	2.4%
Witch[1]	£18,915.98	1.4%	17	1.3%
Saithe[1]	£16,831.33	1.2%	17	1.3%
Lemon sole[1]	£12,178.50	0.9%	5	0.4%
Hallibut[1]	£8,697.64	0.6%	1	0.1%
Ling[1]	£8,172.70	0.6%	6	0.4%
Other[4]	£17,786.91	1.3%	13	1.0%
Total demersal	£368,153.93	26.6%	237	18.1%
Total pelagic	£330,621.30	23.9%	868	66.2%

Table TA3.2.1: Breakdown of average annual value (real 2014 GBP) and liveweight (tonnes) for all species landed from the ICES rectangle 46F1 during 2009 – 2014 [4]

	Value (real 2014 GBP)	Percentage of total value (%)	Liveweight (tonnes)	Percentage of total liveweight (%)
Total shellfish	£686,483.68	49.6%	205.5612	15.7%
Total commercial fish	£1,385,258.91	100.00%	1,311	100.00%

Notes

[1] Landings reported every year for these species

[2] No landings reported in 2013 and 2009 for this species

[3] No landings reported since 2009 for this species

[4] The remaining 1.3% in value and 1% in liveweight is comprised of the following species (in descending order of value): squid, plaice, spurdog, pollack, turbot, megrim, catfish, grey gurnards, mackerel, other or mixed demersal, other flatfish, red mullet, roes, tosck (tuck), skates and rays, redfishes, cuckoo ray, red gurnards, thornback ray, other mullet, gurnard and latchet, octopus, brill, greater forked beard, conger eels and spider crabs.

Nephrops is the species with the highest commercial value, followed by herring and monks (anglers) (monkfish – *Lophiidae* spp). Together with horse mackerel and haddock, these five species account for over 85% of the total landings by value, and over 89% by live weight. This is represented in Figure 3.2.1.

The gear types used for fishing in the Brae Area are trawl and seine nets which were found to account for 100 % of fishing effort in terms of fishing days from 2009 – 2013 (within ICES rectangle 46F1). The shellfish (Nephrops) fishery is the most productive in terms of landings value and the pelagic fishery is the most productive in terms of tonnage [3]

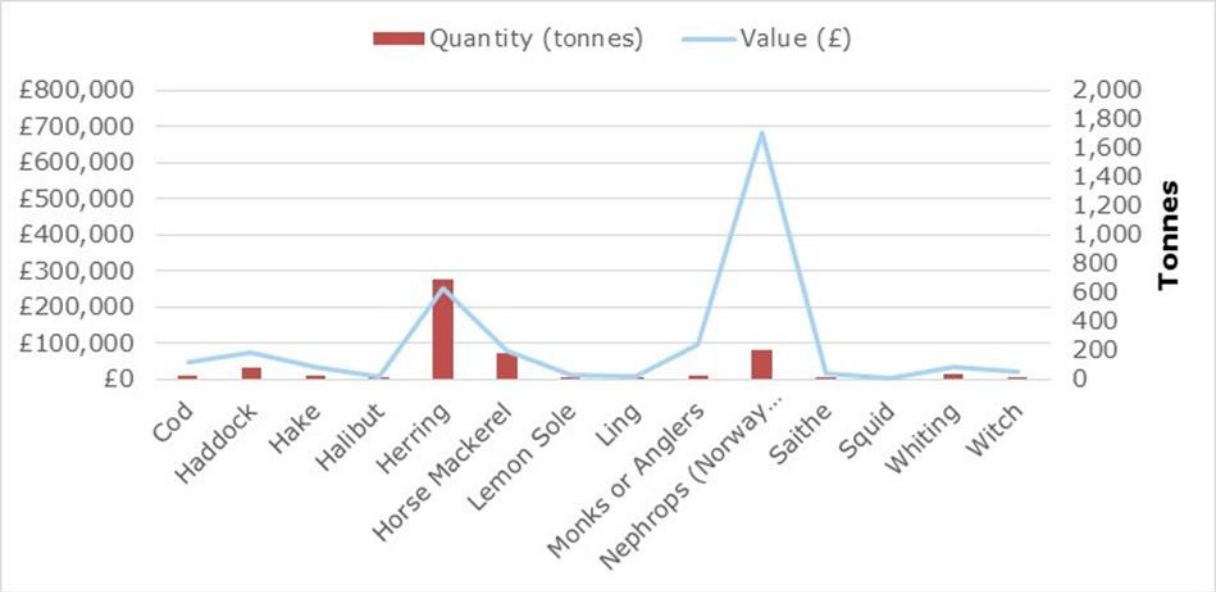

Figure 3.2.1: Annual value (real 2014 £) and liveweight (tonnes) of main species landed from the ICES rectangle 46F1 [4]

The area is estimated to provide between 0.35%[1] landings (by value) to 0.2% landings by value of the Scottish fishing industry [3]. The average annual economic value of fish landings within 12 nm of each jacket is £1,058,842. This highlights the relatively low commercial value of the study area, however, it is of some local importance, particularly for the high value Nephrops fishery. The nearest major commercial UK fishing ports to the Brae Area are Peterhead, Fraserburgh and Lerwick; these ports accounted for 45% by quantity and 39% by value of all landings by UK vessels into the UK in 2011, and are the top three ports in the UK based on quantity landed by UK vessels. Vessels using 46F1 rectangle consistently during 2009-2013 are most likely to originate from Fraserburgh[2] and Peterhead[3]. Approximately 73% of the study area is used for fishing, whereas the remaining 27% areas are not fished due to habitat unsuitability or unsafe ground/snagging risks [3].

Consideration is given to *Nephrops norvegicus* (Norway lobsters) given their economic importance and dominant usage of sediment habitats. They are commonly known as 'prawns' and marketed as Scottish langoustines or scampi, are distributed widely around the Scottish coast, supporting the largest fishery for this species in the world with a value to Scotland of £82 million in 2012 (the second most valuable species after mackerel). The distribution of Nephrops is limited to areas of seabed composed of soft mud in which the animal constructs semi-permanent burrows that provide shelter from predators. The single biggest area of suitable mud and the one supporting the largest Nephrops population is the Fladen Ground located in the northern North Sea to the north-east of Scotland, covering an area of nearly 30,000 square kilometres [4]. The Brae Area lies on the south-eastern edges of the Fladen Ground prawn fishery. Unlike some of the smaller inshore prawn grounds which have been fished for around 50 years, the offshore Fladen Ground fishery has developed more recently and has expanded rapidly in the last 20 years or so. Over recent years, landings have regularly exceeded 10,000 tonnes and the area has supported a fleet of larger prawn trawlers [4]. The study area, with an average annual live weight of 204 tonnes, contributes approximately 2% of this total.

Catch per unit effort from the ICES rectangle 46F1

Fishing effort, measured as the fishing activity of [4]. Effort data includes the time spent travelling to fishing grounds as well as the time spent fishing within the ICES rectangle 46F1. As previously noted, most vessels that actively fished in the study area in the period 2009 to 2013 were registered within the UK [3]; therefore, whilst no information was obtained on fishing effort from non-UK vessels, these are expected to have a small contribution. A Catch per Unit Effort Index (CPUE) was derived to standardize the data, based on the liveweight (tonnes) for all the species landed by UK vessels into the UK and abroad and by foreign vessels into the UK. Due to the aforementioned data limitations, the resulting CPUE may have reduced accuracy as it does not consider fishing effort by non-UK vessels, however information presented below provides some guidance on the performance of vessels travelling to the area over time.

[1] Based on the average 2009 to 2014 value of landings into Scotland by UK vessels, in real 2014 GBP.
[2] 40% of demersal fleet (35 vessels) and 40% of pelagic fleet (4 vessels) estimated to have landed into Fraserburgh from the study area during the period 2009 to 2013
[3] 4% of demersal fleet (25 vessels) and 65% of pelagic fleet (2.6 vessels) estimated to have landed into Peterhead from the study area during the period 2009 to 2013

Table TA3.2.2: Catch per unit effort for all species landed by UK over 10 m vessels from the ICES rectangle 46F1 during 2001 – 2014 [4]

Year	Fishing effort (days) by >10 m UK vessels	Liveweight (tonnes) for all the species landed by UK vessels into the UK and abroad and by foreign vessels into the UK	CPUE
2001	686.61	1,014	1.48
2002	642.80	727	1.13
2003	418.07	407	0.97
2004	409.83	1,719	4.19
2005	547.00	1,822	3.33
2006	426.58	1,101	2.58
2007	487.49	944	1.94
2008	404.92	531	1.31
2009	373.14	754	2.02
2010	521.59	1,229	2.36
2011	402.47	433	1.08
2012	195.12	731	3.75
2013	169.60	391	2.30
2014	276.73	2,041	7.38

Table TA3.2.2 shows a variable but generally declining fishing effort (refer to Figure 3.2.2), however the catch per unit effort index has a predominantly upward trend.

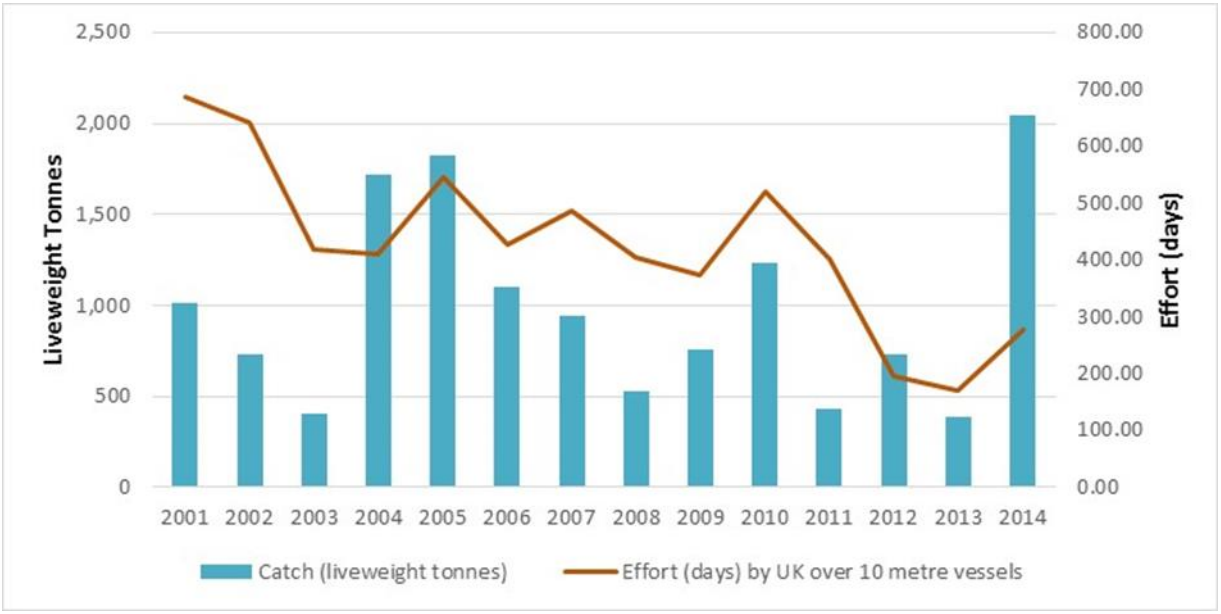

Figure 3.2.2: Evolution of catch and effort from the ICES rectangle 46F1 during 2001 – 2014 [4].

It should be noted that the annual landings of the main commercial species fluctuate significantly over time (refer to Figure 3.2.3), with the sharp increase in CPUE in 2014 driven by the high volume of herring (the species with the second highest commercial value landed from the area). Notably, landings in 2014 (£1.364M) had a similar commercial value to those of 2011 (£1.297M) and slightly lower than those of 2010 (£1.573), largely due to the sharp increase in the price (£/tonne) of Nephrops in 2011 and the decline in the price of herring (halved between 2012 and 2014). Landings in 2013 (£0.731M), 2012 (£0.877M) and 2009 (£1.069M) had a significantly lower commercial value.

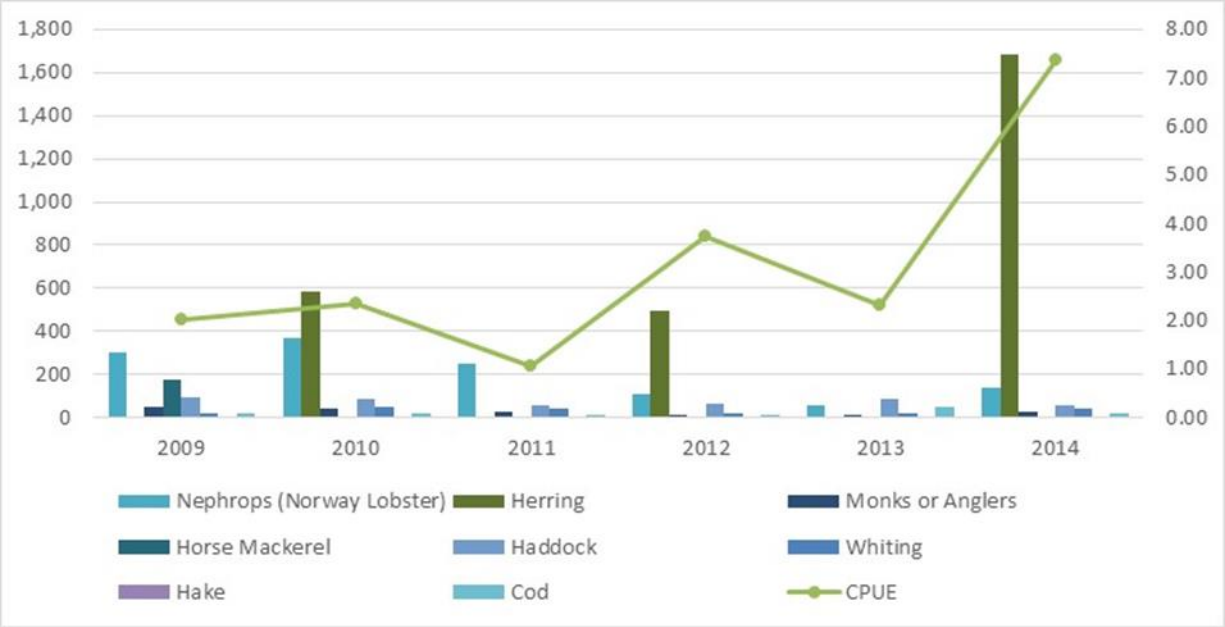

Figure 3.2.3: Evolution of landings from the ICES rectangle 46F1 from the most relevant commercial species during 2009 – 2014 [4].

Technical Appendix 4.1: Scoping Rationale

This technical appendix sets out the scoping rationale identified as a result of the completion of a single, integrated scoping exercise for the decommissioning of the whole of the Brae Area. Potential for significant effects associated with the East Brae and Braemar infrastructure have been brought forward in a separate ES in support of a separate DP for this infrastructure.

The following activities are not proposed as part of the DP and are therefore scoped out of further consideration in the ES.

- full removal of the Brae Alpha and Brae Bravo jacket/sub-structures; and
- removal or relocation of the drill cuttings piles.

Table TA4.1.1: Activity/receptor interactions scoped out for consideration within the Brae Alpha, Brae Central Brae, West Brae and Sedgewick installations EIA due to no impact, negligible or low potential for significant effects

Technical Study Area	Activity/ Receptor Interaction	Infrastructure Affected	Potential for Significant Effect[4]	Discussion
Designated Sites and Species Disturbance	Transportation of Materials and Personnel to and from Brae Area	Brae Alpha, Brae Bravo	Negligible	Transportation of Materials and Personnel to and from the Brae Area would be conducted primarily by helicopter with infrequent vessel use. There is no potential for interaction with designated sites or species associated with helicopter use. Birds are considered to be sensitive to airborne noise (as a result of helicopter movements or vessel movements) which could cause displacement. However the activities associated with the proposed decommissioning are comparable to normal operational movements and background shipping traffic. Given the low frequency at which movements would occur and low magnitude of change e.g. temporary disturbance (with low consequence) for bird populations it is considered unlikely to result in more than a negligible impact.
	Topsides Preparation	Brae Alpha, Brae Bravo	No Impact	Topside preparation activities would have no direct interaction with designated sites or species. Underwater noise from vessels would be comparable to normal operational vessel movements and would not be significant.

[4] *In the case of 'accidental events' the risk grading could be low – high depending on the extent of any accidental event.*

Table TA4.1.1: Activity/receptor interactions scoped out for consideration within the Brae Alpha, Brae Central Brae, West Brae and Sedgewick installations EIA due to no impact, negligible or low potential for significant effects

Technical Study Area	Activity/ Receptor Interaction	Infrastructure Affected	Potential for Significant Effect[4]	Discussion
	Subsea Installations Removal, including removal of marine growth by water jetting	Brae Alpha, Brae Bravo, Area Wide infrastructure	Low	There would be no interaction between the removal of subsea installations and designated sites. Displacement or disturbance of species of interest from noise and vessel presence and decommissioning activities are likely to be low frequency, short duration and as such small magnitude of change for this activity. An evaluation of available ROV footage of the Brae Area infrastructure has been completed. No evidence of biogenic reef forming organisms e.g. *Lophelia* spp has been identified. A further pre-decommissioning survey to check for the presence of designated species will be completed prior to the decommissioning activities taking place. Overall the potential for significant environmental effect is considered to be low.
	Topsides Removal	Brae Alpha, Brae Bravo,	No Impact	Topside removal activities would have no interaction with designated sites or species.
	Drill Cutting Piles (Remove/ Relocate)	Brae Alpha, Brae Bravo	No Impact	Scoped – out not proposed as part of the DP.
	Drill Cutting Piles (left in place)	Brae Alpha, Brae Bravo	No Impact	Drill cuttings piles left in place would have no interaction with designated sites or species. Studies commissioned by Marathon Oil have demonstrated that there is negligible potential for leaching of contaminants into the water column, especially in the absence of disturbance.
	Steel Jacket – Full Removal, including removal of marine	Brae Alpha, Brae Bravo	Low	Scoped out – not proposed as part of the DP.

Table TA4.1.1: Activity/receptor interactions scoped out for consideration within the Brae Alpha, Brae Central Brae, West Brae and Sedgewick installations EIA due to no impact, negligible or low potential for significant effects

Technical Study Area	Activity/ Receptor Interaction	Infrastructure Affected	Potential for Significant Effect[4]	Discussion
	growth by water jetting			
	Steel Jacket – Partial Removal	Brae Alpha, Brae Bravo	Low	Jacket removal activities would have no interaction with designated sites. Displacement or disturbance of species of interest from noise associated with cutting, lifting and general vessel presence and decommissioning activities are likely to be low frequency, short duration and as such small magnitude of change for this activity. Potential effects on marine mammals are assessed in Section 5: Summary of Environmental Effects. An evaluation of available ROV footage of the Brae Area infrastructure has been completed. No evidence of biogenic reef forming organisms e.g. *Lophelia* spp has been identified. A further pre-decommissioning survey to check for the presence of designated species will be completed prior to the decommissioning activities taking place. Overall the potential for significant environmental effect is considered to be low. .
	Pipeline/ Cable/ Flowline and Umbilical (removal or left in place)	Area Wide Infrastructure	Low	Displacement or disturbance of species of interest from noise and vessel presence and decommissioning activities are likely to be low frequency, short duration and as such small magnitude of change for this activity. An evaluation of available ROV footage of the Brae Area infrastructure has been completed. No evidence of biogenic reef forming organisms e.g. *Lophelia* spp has been identified. A further pre-decommissioning survey to check for the presence of designated species will be completed prior to the decommissioning activities taking place. Where infrastructure would be left in place, there would be no potential for interaction with designated sites or species.

Table TA4.1.1: Activity/receptor interactions scoped out for consideration within the Brae Alpha, Brae Central Brae, West Brae and Sedgewick installations EIA due to no impact, negligible or low potential for significant effects

Technical Study Area	Activity/ Receptor Interaction	Infrastructure Affected	Potential for Significant Effect[4]	Discussion
				Overall the potential for significant environmental effect is considered to be low.
Seabed Disturbance Effects (marine benthos, geology, natural seabed sediment and drill cuttings pile)	Transportation of Materials and Personnel to and from Brae Area	Brae Alpha, Brae Bravo	Negligible	Seabed disturbance is likely to be negligible. Transportation using helicopter flights with occasional/ infrequent vessel movements would have no interaction with the seabed.
	Topsides Preparation	Brae Alpha, Brae Bravo	No Impact	No seabed disturbance is predicted during topsides preparation - all operations would be conducted above water.
	Topsides Removal	Brae Alpha, Brae Bravo	Low	There is the potential for physical disturbance to the seabed and suspension of sediment into the water column associated with anchoring vessels. Site survey data would be used to select appropriate anchor locations resulting in a small magnitude of change and, overall, a low impact. Further information on likely effects is provided in Section 5: Summary of Environmental Effects.
	Drill Cutting Piles (left *in place*)	Brae Alpha, Brae Bravo	Low	Survey data used to inform a stage I OSPAR assessment (Recommendation 2006/5) undertaken for each of the drill cuttings piles has confirmed that drill cutting pile sediments fall below the OSPAR screening thresholds. Therefore the drill cutting piles may be left in place to degrade naturally. It is acknowledged that the drill cuttings cover an area of seabed; however the overall area affected is considered to be small in the context of the wider area of mud/sand soft bottom habitat in the Brae Area and the North Sea. Overall the potential for significant environmental effect is considered to be low.
	Pipelines/cables, flowlines/umbilical (left *in place*)	Area wide subsea pipelines/cables,	No impact – Low	It has been assumed that adequately trenched or rock-covered pipelines/cables, flowlines/umbilicals would remain in place in accordance with the Pipelines CA. This would result in no additional impact on natural seabed sediments or benthic communities. Additional trenching in place or rock covering of exposed infrastructure

Table TA4.1.1: Activity/receptor interactions scoped out for consideration within the Brae Alpha, Brae Central Brae, West Brae and Sedgwick installations EIA due to no impact, negligible or low potential for significant effects

Technical Study Area	Activity/ Receptor Interaction	Infrastructure Affected	Potential for Significant Effect[4]	Discussion
		flowlines/umbilicals		may be required; however this would be over a local extent along the area occupied by the existing installation and is considered to represent a low potential to result in significant environmental effect. Further information is provided in Section 5.4.2: Seabed Disturbance of the ES.
	Partial removal – potential to disturb drill cuttings piles	Brae Alpha, Brae Bravo	Low	Removal is proposed above the footings (as described in the DP), therefore there would be no disturbance to the drill cuttings piles.
Noise effects (fish, marine mammals, seabirds)	Transportation of Materials and Personnel to and from Brae Area	Brae Alpha, Brae Bravo	Negligible - Low	Low frequency and small magnitude disturbance to birds flying in the area due to the noise produced by the helicopters. Assessed as low potential for significant environmental effect. Previous studies indicate a very localised and temporary effect on both seabirds and fish associated with helicopter/vessel movements. An infrequent and small magnitude of change would be associated with vessel movements required to transport materials/personnel to and from the Brae Area. The majority of transportation will be by helicopter. Assessed as negligible potential for significant effect on fish or marine mammals.
	Topsides Preparation	Brae Alpha, Brae Bravo	Low	Vessel activity associated with decommissioning has been considered against the existing vessel activity in the area. Topside decommissioning will result in short term vessel noise, which is unlikely to represent more than a small/local change from the operational phase ambient noise (which also includes noise from process equipment and power generation). Based on the likely noise source levels associated with vessel movements, avoidance reactions from almost all fish species are likely to occur in close proximity to the area, however the fish population will return after the cessation of activities. No injurious levels of noise are envisaged and no long-term effects are envisioned.

Table TA4.1.1: Activity/receptor interactions scoped out for consideration within the Brae Alpha, Brae Central Brae, West Brae and Sedgewick installations EIA due to no impact, negligible or low potential for significant effects

Technical Study Area	Activity/ Receptor Interaction	Infrastructure Affected	Potential for Significant Effect[4]	Discussion
				For marine mammals consideration has been given to the potential for temporary or permanent injury, and also the potential for masking effects. It is anticipated that mammals in the area are already habituated to noise generated by operational activities at the platform, including vessel movements. It is likely that there would be short term avoidance responses from mammals within a close proximity to vessels e.g. 300 m, however no temporary or permanent injurious effect is anticipated. As a result a low potential for significant environmental effect has been identified. Detailed assessment of underwater noise for cutting activities is provided in Section5 5: Summary of Environmental Effects.
	Drill Cutting Piles (left in place)	Brae Alpha, Brae Bravo	No Impact	No underwater noise source if drill cuttings piles left in place. No impact.
	Pipeline/ cable/ flowline/ umbilical – left in place	Area wide infrastructure	No Impact	No underwater noise source if installations left in place. No impact.
Water Quality Effects (water quality, plankton, fish, shellfish, marine mammals)	Transportation of Materials and Personnel to and from Brae Area	Brae Alpha, Brae Bravo	No Impact	There are no planned discharges to sea associated with transportation of materials and personnel by helicopter or supply vessel that fall within the scope of the DP. Negligible pollution to water quality associated with vessel use. No impact is anticipated.
	Topsides Preparation	Brae Alpha, Brae Bravo	No Impact	Any discharges to sea from topsides preparation will be managed under the operational permitting regime (e.g. The Offshore Petroleum Activities (Oil Pollution Prevention and Control) Regulations 2005 (as amended), Offshore Chemical Regulations 2002 (as amended)). As such, these discharges do not fall within the scope of the DP and have been scoped out of the decommissioning EIA.

Table TA4.1.1: Activity/receptor interactions scoped out for consideration within the Brae Alpha, Brae Central Brae, West Brae and Sedgwick installations EIA due to no impact, negligible or low potential for significant effects

Technical Study Area	Activity/ Receptor Interaction	Infrastructure Affected	Potential for Significant Effect[4]	Discussion
	Topsides Removal	Brae Alpha, Brae Bravo	Negligible	Topsides will be cleaned to an appropriate level. Other stored chemicals or potential contamination sources present during operation of the platforms will have been removed during the topsides preparation for decommissioning. As such there will be negligible sources of pollution associated with the topside removal activity. Any discharges of waste water, chemicals and oils to sea will be managed and assessed under the existing permitting regime (e.g. The Offshore Petroleum Activities (Oil Pollution Prevention and Control) Regulations 2005 (as amended), Offshore Chemical Regulations 2002 (as amended) Chemical Permit). As such, these discharges have been scoped out of the decommissioning EIA.
	Pipeline/ cable/ flowline/ umbilical – left in place	Brae Alpha, Brae Bravo	Negligible	Any discharges to sea from the cleaning of pipelines/flowlines will be managed and assessed under the existing permitting regime (e.g. The Offshore Petroleum Activities (Oil Pollution Prevention and Control) Regulations 2005 (as amended), Offshore Chemical Regulations 2002 (as amended) Chemical Permit). As such, these discharges have been scoped out of the decommissioning EIA.
	Drill Cutting Piles (left in place) Steel Jacket – Partial Removal Subsea installations (associated with platform)	Brae Alpha, Brae Bravo	Negligible	The DP includes for removal of the sub-structure above the footings (as described in the DP), with drill cuttings piles left in place. Subsea infrastructure (including surface laid pipelines, umbilicals, cables, flowlines) would be left in place where they are within a post-decommissioning safety zone. Additional mattress protection may be added (by re-using existing mattresses) within the post-decommissioning safety zone; however no mattresses would be added within the footprint of the drill cuttings piles. By taking this approach, effects on the drill cuttings piles and water quality through disturbance are avoided. Studies commissioned by Marathon Oil have demonstrated that there is negligible potential for leaching of contaminants into the water column, especially in the absence of disturbance. On this basis, water quality effects associated with the drill cuttings have been scoped out of the EIA.

Table TA4.1.1: Activity/receptor interactions scoped out for consideration within the Brae Alpha, Brae Central Brae, West Brae and Sedgewick installations EIA due to no impact, negligible or low potential for significant effects

Technical Study Area	Activity/ Receptor Interaction	Infrastructure Affected	Potential for Significant Effect[4]	Discussion
Socio-economic and Other Effects (commercial fisheries, shipping/ navigation, recreation, marine archaeology)	Topsides Preparation	Brae Alpha, Brae Bravo	Negligible	Operations would take place only on the platforms. There is no potential for interaction with other sea users.

Table TA4.1.1: Activity/receptor interactions scoped out for consideration within the Brae Alpha, Brae Central Brae, West Brae and Sedgewick installations EIA due to no impact, negligible or low potential for significant effects

Technical Study Area	Activity/ Receptor Interaction	Infrastructure Affected	Potential for Significant Effect[4]	Discussion
	Platform subsea installations removal; Topsides Removal; Drill Cutting Piles (Remove/ Relocate; Drill Cutting Piles (left in place); Steel jacket – full removal; Subsea Installations Removal; Pipeline/ cable/ flowline/ umbilical – removal and left in place	Brae Alpha, Brae Bravo	No impact	There is an existing 500 m safety zone in place around the jacket/sub-structures, and this will remain in place for the duration of the decommissioning works to avoid conflict with navigation or commercial fishery interests. As such there would be no change from ambient conditions. Drill cuttings would be left in place along with the jacket/sub-structure footings. In this scenario a post decommissioning safety zone would be established around the jacket/sub-structures. Leaving the footings of the Brae Alpha and Brae Bravo jacket/sub-structure in place will avoid disturbance of the drill cuttings pile. This minimises the risk of dispersing the drill cuttings more widely in the environment, and minimises the risks to personnel carrying out the decommissioning work. The area of remaining restriction to fishing activity is considered to be negligible. The average annual economic value of fish landings within study area is £1,058,842 (2013). This represents a small component (0.2%) of the total landings value by Scottish vessels in 2013, further highlighting the relatively low commercial value of the study area. The current safety zones jacket/sub-structures represent less than 0.05% of the total area provided by the ICES rectangle 46F1. Where pipelines/cables/flowlines/umbilicals are proposed to be left in place, outside of 250 m from the jacket/sub-structure footings, it is assumed that they would be either trenched or suitably rock covered such that they would be over-trawlable and there would be no interaction with commercial fishery interests. It has been assumed that adequately trenched or rock covered pipelines would remain in place in accordance with the Pipelines CA. Further information on the baseline fishing interest is summarised in Technical Appendix 4.2. There are no RYA racing areas, sailing areas, recreational cruising routes, dive sites, sea angling sites, windsurfing locations or education research locations in the area.

Table TA4.1.1: Activity/receptor interactions scoped out for consideration within the Brae Alpha, Brae Central Brae, West Brae and Sedgewick installations EIA due to no impact, negligible or low potential for significant effects

Technical Study Area	Activity/ Receptor Interaction	Infrastructure Affected	Potential for Significant Effect[4]	Discussion
				No designated wreck sites or known marine archaeological features are located within the Brae Area.

Table TA4.1.1: Activity/receptor interactions scoped out for consideration within the Brae Alpha, Brae Central Brae, West Brae and Sedgwick installations EIA due to no impact, negligible or low potential for significant effects

Technical Study Area	Activity/ Receptor Interaction	Infrastructure Affected	Potential for Significant Effect[4]	Discussion
Atmospheric Emission Effects (energy use, climate change, air quality)	All activities	Brae Alpha, Brae Bravo	No impact	Energy use and emissions associated with helicopter or vessel movements during the decommissioning works would not result in significant effects in terms of air quality or climate change effect. Potential for emissions with global warming potential (GWP) and the potential to contribute to climate change have been considered. Emissions with GWP anticipated as a result of Brae Area decommissioning activities include (but are not limited to) carbon dioxide (CO_2) associated with vessel emissions. In addition nitrogen oxide (NO_x) emissions associated with vessel emissions can result indirectly in an increase in ozone (0_3) and nitrous oxide (N_20). Given the meteorological conditions, emissions will likely disperse rapidly. All vessels will comply with MARPOL 73/78 Annex VI on air pollution; plant will comply with relevant air pollution regulations. Preliminary energy use and emissions calculations have been completed to inform the comparative assessment (CA) process and have been given due account within the Comparative Assessment decision making process. As such the potential to minimise emissions to As Low as Reasonable Practicable (ALARP) is already inherent within the DP. Overall, the potential emissions associated with decommissioning would represent a reduction in emissions relative to the normal operational emissions associated with operating the Brae Area platforms and infrastructure. For example, calculations indicated that the total emissions associated with the partial removal of the Brae Alpha jacket/sub-structure using a heavy lift vessel would be approximately 65,000 tonnes CO_2, set against an annual operational energy use generating of 288,869 tonnes CO_2 (i.e 22.5%). Localised air quality sensitive receptors in close proximity to the Brae Area are limited. Human receptors will be limited to offshore operators on vessels and/or nearby

Table TA4.1.1: Activity/receptor interactions scoped out for consideration within the Brae Alpha, Brae Central Brae, West Brae and Sedgewick installations EIA due to no impact, negligible or low potential for significant effects

Technical Study Area	Activity/ Receptor Interaction	Infrastructure Affected	Potential for Significant Effect[4]	Discussion
				infrastructure. Ecological receptors would be limited to seabirds which would be transient through the area. Contributions of the emissions would be at a local scale, within approximately 100m of the source. In addition, due to the offshore location and dominant wind climate (Beaufort 4 – 6) emissions would disperse rapidly. On this basis the overall potential for significant environmental effect is considered to be negligible. The potential for significant effect as a result of this activity/receptor interaction has therefore been scoped out of the EIA.
Accidental Events	Transportation of Materials and Personnel to and from Brae Area	Brae Alpha, Brae Bravo	Low	There is only potential for accidental spills in the event of a transport accident. This is considered to be a highly infrequent/remote possibility with a potential medium magnitude of change. Overall the risk of accidental spill is considered low.
	Drill Cutting Piles (left in place)	Brae Alpha, Brae Bravo	Low	The only accidental event that might occur would be linked to dropped items or water jetting of steel jackets and other infrastructure resulting in unintended/unplanned disturbance to the drill cuttings piles. A Stage 1 OSPAR assessment (under the terms of OSPAR Recommendation 2006/5) was undertaken in 2008 (updated in 2015 following sampling) and concluded that the drill cutting piles fall below the thresholds set out within this recommendation and could therefore be left in place to degrade naturally. Any accidental mobilisation of contaminants would be short term and localised, and therefore low risk.
	Pipelines / Cables / Flowlines / Umbilicals – left in place	Brae Alpha, Brae Bravo	Negligible	It has been assumed that only adequately trenched or rock-covered pipelines would remain in place in accordance with DECC guidelines (DECC, 2011), unless the lines are located within the proposed post-decommissioning safety zone. This is because where surface laid lines are located within a post-decommissioning safety zone, the risk posed to fishermen by leaving the line in place has been assessed to be lower than the risk to

Table TA4.1.1: Activity/receptor interactions scoped out for consideration within the Brae Alpha, Brae Central Brae, West Brae and Sedgewick installations EIA due to no impact, negligible or low potential for significant effects

Technical Study Area	Activity/ Receptor Interaction	Infrastructure Affected	Potential for Significant Effect[4]	Discussion
				decommissioning personnel involved in remediating the line. The risk to fishermen is mitigated by the line being located in a proposed post-decommissioning safety zone. Leaving a portion of pipelines/ cables/flowlines/umbilicals in place within the post-decommissioning safety zone minimises the risk of accidental disturbance to drill cuttings piles. Additional rock cover would be added where necessary to reduce the potential risk associated with 'snagging' of fishing nets. The result is a negligible risk of significant environmental effect.

Table TA4.1.2: Activity/receptor interactions scoped in for consideration within the Brae Alpha, Brae Bravo and wider subsea installations EIA due to potential for significant effects

Technical Study Area	Activity/receptor interaction	Infrastructure affected	Potential for Significant Effect[5]	Discussion
Seabed Disturbance	Seabed Disturbance Effects (marine benthos, geology, natural seabed sediment and drill cuttings pile during removal of subsea installations and additional rock placement.	Brae Alpha, Brae Bravo, and Area wide subsea installations	Medium	Seabed disturbance would occur throughout the duration of the decommissioning programme, associated with a range of proposed decommissioning activities. This would result in the potential mobilisation of sediment into the water column. The benthic communities in the Brae Area typically comprise deeper water sand communities. Typical species may include Priority Marine Features as defined by the Marine (Scotland) Act 2010. The potential for significant effect on this assemblage remains scoped in to the EIA.
Underwater Noise	Pipeline and subsea installation removal and potential to produce underwater noise with effects on noise sensitive marine mammals.	Pipeline and other subsea installations	Medium	Marine mammals are considered to be highly sensitive and have the potential to be affected by the noise and presence of vessels, directly, or indirectly through prey displacement. In general, marine mammals are considered to show the highest sensitivity to noise, although effects on fish species such as cod and herring remain possible over 4-5km from source. All cetaceans are listed in Annex IV of the EC Habitats Directive (92/43/EEC) as species being in need of strict protection. In general, the area has lower densities of marine mammals than in other areas, though numbers are likely to increase during the summer months. It is noted that the North Sea contains some of the busiest shipping routes in the world, though the Brae Area is relatively light, dominated by oilfield supply boats and fishing boats. However, the frequent movement of vessels and industrial activities in the area indicates that the species present would be tolerant to vessel presence and associated impacts.

[5] *In the case of 'accidental events' the risk grading could be low – high depending on the extent of any accidental event.*

Table TA4.1.2: Activity/receptor interactions scoped in for consideration within the Brae Alpha, Brae Bravo and wider subsea installations EIA due to potential for significant effects

Technical Study Area	Activity/receptor interaction	Infrastructure affected	Potential for Significant Effect[5]	Discussion
				The duration or effects is considered to be short term due to the common occurrence of vessel movements in the North Sea, it is considered that should any impacts associated with displacement and disturbance occur, the species would recover and return to these locations at the cessation of the decommissioning activities. Noise from the vessels and cutting activities may displace/disturb marine mammals (and to a lesser extent, fish) in the immediate vicinity and in the wider area (due to noise travelling long distances underwater). Overall the effect of cutting operations means that the potential for significant effect remains medium and is scoped in to the EIA.
Noise Effects (marine mammals)	Partial removal of the jacket/sub-structure and potential to affect noise sensitive species of marine mammals.	Brae Alpha, Brae Bravo	High	It is anticipated that noise generation from cutting operations would result in underwater noise which would represent a potential change from ambient conditions. These works have the potential to result in noise impacts to marine mammals (disturbance and/or displacement). Early calculations completed in relation to this activity indicated the potential for behaviour disturbance to marine mammals from cutting over a range of up to 10 km. Disturbance from vessel noise may extend up to 3 km for larger crane vessels. As such, jacket/sub-structure removal is considered to have a high potential to result in significant environmental effect on marine mammals and is scoped in to the EIA

Table TA4.1.2: Activity/receptor interactions scoped in for consideration within the Brae Alpha, Brae Bravo and wider subsea installations EIA due to potential for significant effects

Technical Study Area	Activity/receptor interaction	Infrastructure affected	Potential for Significant Effect[5]	Discussion
Accidental Events	Accidental release of contaminants affecting water quality with secondary effects on marine ecosystems. Risk of accidental spills associated with vessel activities. Risk of dropped objects, particularly during lift operations.	All activities	Low-High	There is the potential for an unplanned spill (hydrocarbons, hazardous materials or cleaning materials) which would result in elevated levels of contaminants reaching water column and seabed. Scale of spill would be dependent on activity and chemicals/contaminants being handled, as such there is range of risk from low to high. Further consideration will be given to the potential for significant environmental effect from accidental or unplanned events as part of the EIA process. Consideration will also be given to dropped objects. There would be no risk for shipping or fishing activities during lift activities, on the basis that an exclusion zone would remain in place during the decommissioning activities, preventing any interaction with general vessel movements or fishing vessels. Objects dropped during lifting operations would potentially impact upon the benthic communities within the drop zone, or result in potential damage to infrastructure (e.g. pipelines) left in place on the seabed within post-decommissioning safety zones. However the benthic fauna present would be likely to recover rapidly (within 1 year) following any disturbance. Pipelines would be flushed/cleaned to an appropriate standard prior to the potential for any dropped objects, therefore the potential for effects from any discharges from damaged pipelines would be low.

Technical Appendix 4.2: Accidental Events

Scope of the Assessment

The key issues identified to fall within the scope of the EIA include:

- accidental release of contaminants during decommissioning activities;
- accidental spills associated with vessel activities (whilst in the Brae Area); and
- risk of dropped objects during decommissioning, particularly associated with lift operations.

The principal sources of contaminants or spills are considered to be hydrocarbons (e.g. crude oil, vessel fuel oil, aviation fuel, other diesels or oils used on the platforms or on decommissioning vessels) and chemicals.

Legislation and Policy Context

Marathon Oil as operator of an offshore installation must comply with the legislative requirements as set out under both the Merchant Shipping (Oil Pollution Preparedness, Response and Co-operation Convention) Regulations 1998 and the Offshore Installations (Emergency Pollution Control) Regulations 2002. To meet these requirements Marathon Oil has produced Oil Pollution Emergency Plans (OPEPs) for the current operation of Brae Alpha and Brae Bravo. Whilst the current OPEPs do not specifically cover decommissioning operations, new OPEPs would be produced for the decommissioning stage.

There are no legislative or policy requirements specifically related to the consideration of accidental events within environmental assessment of decommissioning activities, however 'potential significant effects' on the environment, may include accidental events.

Issues Identified during Consultation

No consultation responses have been received during the EIA process relating to accidental events and therefore no additional issues have been identified beyond those described in the Scoping Report.

Issues Scoped Out

As described in Technical Appendix 4.1: Scoping Rationale of this ES, accidental events associated with the transport of material to or from and within the Brae Area are considered to be highly infrequent/of remote possibility and of a magnitude limited by the quantities of fuel oil and/or other hydrocarbons anticipated to be on board transport vessels. Any spill during transit will be managed through the implementation of the appropriate MARPOL Shipboard Oil Pollution Emergency Plan (SOPEP). Consequently, accidental events from decommissioning vessels in transit have been scoped out from further assessment.

In addition, the ES assumes that the drill cuttings piles beneath both Brae Alpha and Brae Bravo will be left in place to degrade naturally in accordance with the findings of the Stage 1 OSPAR Assessment (2008 and 2015). Consequently it has been assumed that any accidental mobilisation of drill cutting contaminants would be limited to disturbance as a result of dropped objects or from physical disturbance during jet cutting. Any other forms of accidental disturbance have been scoped out from further assessment.

Potential for small scale leaks and spills (e.g. from machinery used in decommissioning works or hoses/lines on the platforms) during the decommissioning works will be mitigated by industry standard best practice procedures and are not considered likely to result in significant adverse effects. Small scale leaks and spills have therefore been scoped out from further assessment.

Topside preparation has been taken to include activities required to ensure hydrocarbons have been removed; all processing plant has been shut down and isolated from the reservoir. These will be carried out under the terms of the existing operational permits and are covered by the existing operational OPEPs. Consequently, whilst there remains the potential for an unplanned spill which would result in elevated levels of contaminants reaching the water column and seabed, any such event will be covered by existing accidental events procedures and are therefore not considered further here.

Assessment Methodology

Baseline Characterisation

Data used to inform this chapter are derived primarily from the analysis of historic data on hydrocarbon and chemical spills collected by the UK Government (Department of Business Energy and Industrial Strategy (BEIS), formerly known as the Department of Energy and Climate Change (DECC)) through the Petroleum Operations Notices (PONs) system. This data has been analysed for the UK offshore area as a whole and specifically for the Brae Area in order to establish an understanding of the current frequency and magnitude of hydrocarbon and chemical spills in the study area and how these compare to the wider UK offshore area.

Method of Assessment

The method of assessment for accidental events takes into account both of the likelihood of an event occurring, and then also given consideration to the potential for significant effect should an event occur.

The methodology draws where appropriate from existing hydrocarbon spill modelling undertaken for the Brae Area operational Oil Pollution Emergency Plans. This has been limited to OPEP modelling associated with diesel spills. For the purposes of this assessment it has been assumed that all well Plug and Abandonment (P&A) has been completed and the Brae Area cleared of significant quantities of crude oil product.

Baseline Conditions

Current Baseline

The current baseline represents a period in which most infrastructure in the UK offshore area (including the Brae Area) has been in the exploration or production (i.e. operational) phase of their life cycles. Data collated by BEIS quantifies hydrocarbon and chemical releases for the UK offshore area[6].

Hydrocarbon Releases

Aggregated data for hydrocarbon releases in the UK offshore area between 2010 and 2015 is shown in Figure 4.2.1. Comparable data relating to operations in the Brae Area between 2010 and 2015 are shown in Figure 4.2.2. All data accessed 10 March 2016.

[6] *Operators are currently required to submit data on oil and chemical releases and Permitted Discharge Notifications (PDNs) from offshore installations and pipelines to BEIS via the Petroleum Operations Notices (PONs) system. BEIS, as the offshore environmental regulator, requires operators to submit details of all chemical and oil releases/spills to sea, regardless of quantity. This information is submitted by operators using a Petroleum Operations Notice 1 (PON1).*

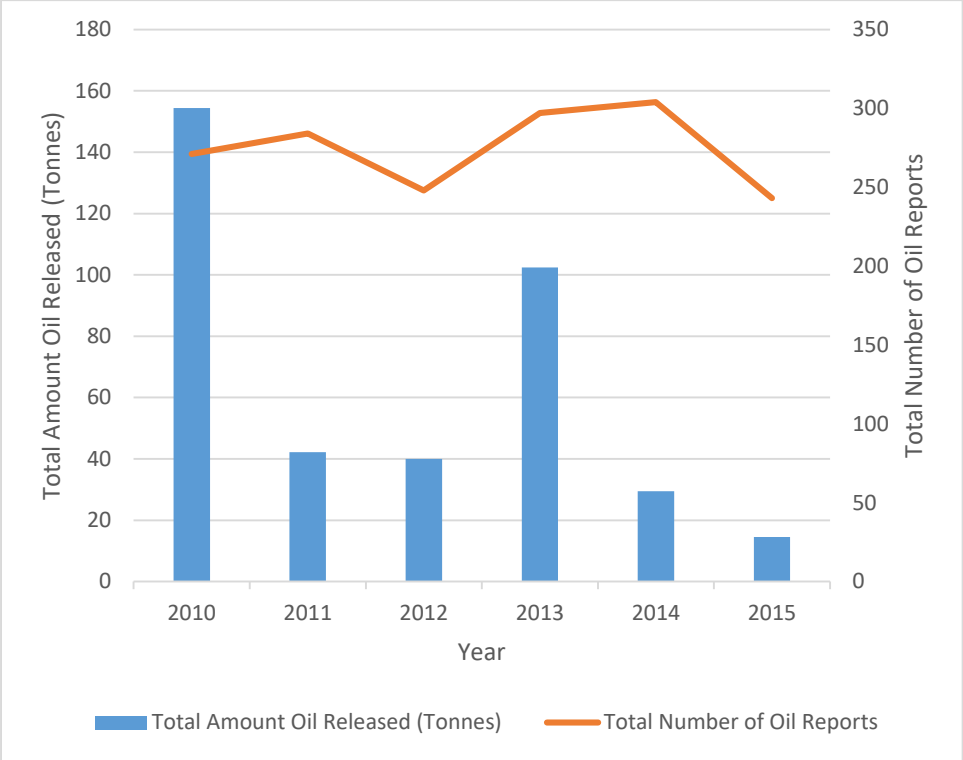

Figure 4.2.1: Volume and Number of Hydrocarbon Releases, UK Offshore Area 2010 – 2015

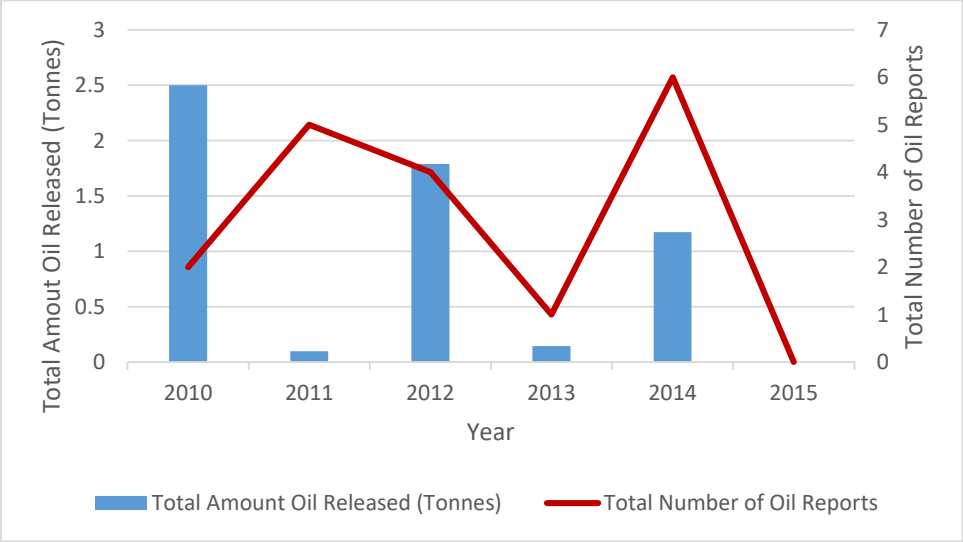

Figure 4.2.2: Volume and Number of Hydrocarbon Releases, Brae Area 2010 – 2015

Figure 4.2.1 indicates the total amount of hydrocarbon released each year in the UK offshore area has been in a gradual decline. Data for the Brae Area (Figure 4.2.2) covers a shorter time period and show annual fluctuations in the number and volume of hydrocarbon releases.

Between 2010 and 2015 all but one recorded releases of hydrocarbons from the Brae Area involves hydrocarbon volumes of less than one tonne.

Chemical Releases

Aggregated data for chemical releases in the UK offshore area between 2010 and 2015 is shown in Figure 4.2.3. Comparable data relating to operations in the Brae Area between 2010 and 2015 are shown in Figure 4.2.4. (All data accessed 10 March 2016).

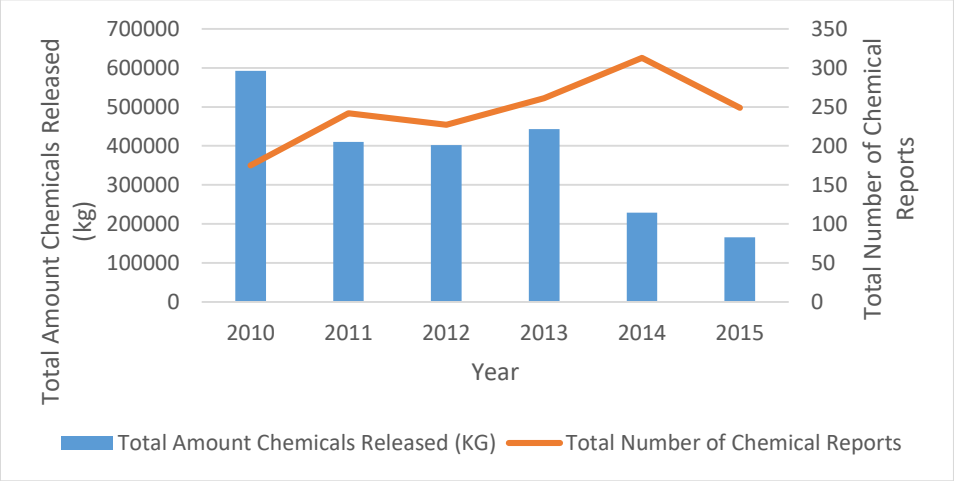

Figure 4.2.3: Volume and Number of Chemical Releases, UK Offshore Area 2010 – 2015

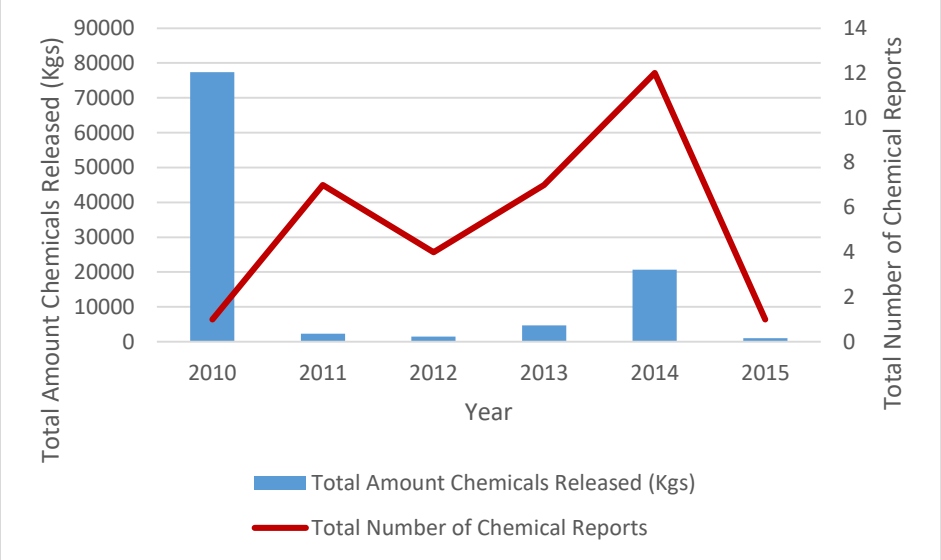

Figure 4.2.4: Volume and Number of Chemical Releases, Brae Area 2010 – 2015

Figure 4.2.3 indicates a small increase in the number of chemical releases in the UK offshore area between 2010 and 2015, but indicates that the total volume of chemicals released has been steadily declining. Data for the Brae Area shows an annual fluctuation in the number and quantity of release, illustrated in Figure 4.2.4.

Future Baseline

The data presented above represents a period in which most infrastructure in the UK offshore area (including the Brae Area) has been in the exploration or production (i.e. operational) phase of their life cycles. For the purposes of this assessment, it remains reasonable to assume that the evident current trend of a gradual reduction in hydrocarbon and chemical spill volumes will continue over the medium

to long term, reflecting the anticipated overall decrease in oil and gas production in the UK North Sea and therefore a decrease in the number of operational wells and platforms.

The timeframe for the Brae Area decommissioning schedule is currently anticipated to be between 2020 and 2031 (see section 6.3 of the DP), although this schedule may change to maximise economic recovery, or to exploit opportunities to minimise decommissioning impacts by combining Brae Area decommissioning activities into campaigns, or by combining Brae Area decommissioning operations with third party decommissioning. However it is reasonable to assume that the baseline conditions at the time in the UK offshore area as a whole will either be similar to conditions at the present time, or that the number and volume of leaks and spills will have declined slightly.

Potential Impacts: Hydrocarbon Spills

Potential Sources of Hydrocarbon Spills

Hydrocarbon leaks or spills could occur from a range of different sources:

- Accidental release of fuel oils from vessels involved in decommissioning works (whilst in the Brae Area), machinery/plant used in decommissioning works may occur. A range of vessel types and sizes would be required to facilitate the proposed decommissioning activities. The risk of accidental spills of fuel oils from vessel activity will remain throughout the decommissioning programme.
- Mobilisation of hydrocarbon contaminants within the drill cuttings piles may occur in the event of unanticipated disturbance of drill cuttings (e.g. associated with dropped objects);

Spills of significant quantities of Brae crude oil are not expected during decommissioning activities.

Impact Assessment

The magnitude and significance of effects of a hydrocarbon spill during decommissioning activities may vary widely based upon a combination of factors including: the substance spilled and its characteristics; the volume spilled; the source of the spill relative to the surface (e.g. subsurface or at surface); sea state; weather conditions and wind direction; the speed and effectiveness of spill response and the sensitivity of receptors affected. Consequently it is not possible to produce a single impact assessment of the significance of potential adverse effects as there are a large number of possible permutations and each spill has the potential to be different to another.

As part of the OPEPs prepared for the Brae Area operations, oil spill modelling was undertaken for current operational conditions. Care has been taken throughout this assessment in interpreting operational OPEP modelling results and in drawing any inference as to likely oil spill behaviour during decommissioning. It is also acknowledged that volumes and spill sources modelled may differ from those that could feasibly occur during decommissioning.

A summary of the results of this modelling specifically for diesel fuel is set out below.

Diesel Spillage Scenarios at Brae Alpha and Brae Bravo

Diesel and aviation fuel evaporates quickly on release. The low asphaltene content prevents emulsification reducing its persistence in the marine environment. Due to their characteristics and subsequent behaviour when released, diesel oil and aviation fuel are not considered to offer a significant threat to the environment when compared with the risks posed from an operational spill of Brae field crudes.

For diesel spills at Brae Alpha, two scenarios were modelled within the operational OPEP. :

- Scenario 1: an immediate release spill of 1,823 m^3 from the Brae Alpha platform location, in winter with a sea temperature of 6°C, air temperature of 4°C and wind speed of 30 knots, with wind direction of 55 degrees.
- Scenario 2: an immediate release spill of 1,823 m^3 from the Brae Alpha platform location, in winter with a sea temperature of 6°C, air temperature of 4°C and wind speed of 30 knots, with wind directions of 260 degrees.

The modelling indicated that in both cases the diesel persisted for 8 hours before dispersing naturally into the environment. During that time the spill attained a maximum length of 7 km. The modelled spill did not beach or cross into the Norwegian sector. Results indicated that 729-734 m^3 evaporated and 1090-1095m^3 dispersed into the upper layers of the water column. It is estimated that the impact to marine biological resources would be localised and those impacted would be likely to be subjected to toxic short term non persistent effects.

Similar results were found for diesel spills at Brae Bravo with an immediate release spill volume of 1,312 m^3 under the same set of sea state and weather conditions described above. In westerly winds from 260 degrees modelling results indicate that the diesel would persist for 8 hours and reach a length of 14.8 km before dispersing naturally into the environment. The spill would encroach into Norwegian waters crossing the Median line after approximately 5 hours from release. In north easterly winds from 55 degrees the diesel would reach a length of 7km and would not enter Norwegian waters. In both cases results indicated that almost all of the hydrocarbon would either evaporate or be dispersed into the upper layers of the water column over a 10 day period, with an insignificant volume (max 9 m^3) remaining on the surface after this time.

The volume of diesel that would be present in the Brae Area during decommissioning activities cannot be known at present and would vary depending upon the stage of the works and therefore number of vessels in the area. Therefore a worst case scenario spill during decommissioning may differ from that described above.

An updated OPEP will be prepared by Marathon Oil for the decommissioning phase.

IMPACTS TO BIOLOGICAL RECEPTORS

For spills at the sea surface, planktonic and benthic communities are unlikely to be affected as the type of hydrocarbons that could be spilled comprise diesels that have quick rates of evaporation and crudes that would stay at or near the surface.

The greatest potential for significant adverse effects associated with a diesel fuel spill is for species that would be found at or near the surface including seabirds, fish and marine mammals. Table TA4.2.1.1 provides a summary of the likely effects associated with accidental events.

Table TA4.2.1: Likely Effects

Receptor	Potential Effects
Fish	Several fish species are known to be present in the wider vicinity of the Brae Area and use the area for spawning and/or nursery grounds; these include the Norway pout, Nephrops, mackerel, haddock and blue whiting. Spawning grounds extend over large areas of the North Sea, with eggs often developing on the seabed or in the water column, making them vulnerable to pollutants and disturbance. Peak spawning in the Brae Area for Nephrops, mackerel and blue whiting occurs between April to June/July, and for Norway pout between February to April. All of the above species are also found widely over this part of the North Sea. Potential diesel spills would be limited in extent, correspondingly limiting the proportion of any population affected. No significant effect is expected.
Marine Mammals	Seven species of marine mammals (cetaceans and pinnipeds) are regularly sighted in the proximity of the Brae Area including grey seal, harbour seal, harbour porpoise, Atlantic white-sided dolphin, white-beaked dolphin, Risso's dolphin, killer whale, minke whale and long-finned pilot whale. The species found in the Brae Area are also found within the wider North Sea. All of the species are recorded at low densities in the Brae Area. Potential diesel spills would be limited in extent, correspondingly limiting the proportion of any population affected.
Birds	Seabirds are present in the central and northern North Sea throughout the year, though densities in the Brae Area tend to be lower due to the distance from coastal colonies. Seabird densities in the Brae Area are at their lowest in late spring/early summer when many birds are at their coastal colonies nesting, and foraging distances out to sea are reduced. At the end of the breeding season, the diversity and density of seabirds offshore increases as breeding birds leave their colonies and disperse into the North Sea. Birds and their chicks are particularly vulnerable to surface pollutants when they are gathering for breeding season and when they undergo a moult of primary feathers (which leaves them flightless). Physical fouling of feathers, damage to eyes and toxic effects of ingesting hydrocarbons can result in direct and indirect fatalities. Any effects would depend on size of spill, on the species present, their abundance and the time of year.

Diesel spills are not expected to reach either the UK or Norwegian shoreline in the scenarios modelled for the operational phase OPEPs.

IMPACTS TO SOCIO-ECONOMIC (COMMERCIAL FISHING) RECEPTORS

The principal target commercial species comprise the following:

- Pelagic species such as herring, mackerel, horse mackerel;
- Demersal species such as cod, haddock, whiting and saithe; and
- Shellfish such as Nephrops.

Spawning and nursery grounds for various commercially important species are located in the vicinity of the Brae Area, including cod, haddock, Norway pout, saithe, Nephrops and mackerel. Potential for biological effects on fish species has been discussed above.

Fishing vessels would be excluded from the area of the spill whilst hydrocarbons were still on the surface and may also be excluded for a period after the spill has been treated or cleaned up in order to allow any remaining hydrocarbons to disperse. Depending upon the time of year the significance of this exclusion would vary in terms of loss of income from landings, as certain times of the year are more critical for fisheries than others. Whilst the fishery in and around the Brae Area is locally commercially important to fleets from Fraserburgh and Peterhead (the area represents approximately 0.2% of landings (by value) of the Scottish fishing industry), there are other fishery areas available nearby. Any exclusion from the area of a spill would be temporary and short term.

The North Sea contains some of the busiest shipping routes in the world though a significant proportion of the shipping activity consists of ferries and vessels on fixed routes. Vessels would be temporarily excluded from the area of a spill whilst the spill response effort is in progress, however as described above spills during decommissioning would be expected to last only a small number of day on the surface without treatment. Whilst vessels may have to adjust course to avoid the spill area, this effect would be temporary and localised and is unlikely to result in significant adverse effects on commercial shipping.

In respect of recreation and tourism, activities in the offshore North Sea are limited to occasional yachts in passage. As recreational activity is very low, whilst recreational vessels would be temporarily excluded from the area of a spill as described above, the localised nature and short duration of this effect would mean that only a very small number of recreational users would be likely to be affected.

Potential Impacts: Chemical Spills

Potential Sources of Chemical Spills

Chemical leaks or spills could occur from a range of potential sources including residual chemicals left behind on the topsides and infrastructure being decommissioned and dismantled; and also vessels involved in decommissioning works (whilst in the Brae Area) and machinery/plant used in decommissioning works.

Potential sources of chemical spills included in this assessment are: accidental releases of contaminants during topside preparation and removal; releases during decommissioning of subsea installations and pipelines/flowlines/cables/umbilicals removal; and accidental spills associated with vessel activities whilst in the Brae Area.

Accidental events associated with the transport of material to or from the Brae Area and with pipelines/flowlines/cables/umbilicals (if left in place) have been scoped out of assessment. Small scale leaks and spills during the decommissioning works are not assessed here as it is not considered that these have the potential to cause significant adverse environmental effects.

Topside preparation has been taken to include activities required to ensure chemicals have been removed; all processing plant has been shut down and isolated from the reservoir. There is the potential for an unplanned spill which would result in elevated levels of contaminants reaching the water column and seabed.

A range of vessels of various types and sizes will be required to facilitate decommissioning activities. The risk of accidental spills from vessel activity will remain throughout the decommissioning programme particularly associated with, but not limited to, topside preparation, topside removal and jacket/sub-structure removal.

Impact Assessment

The magnitude and significance of any effects of a chemical spill could vary significantly based upon a combination of factors including the substance spilled and its characteristics (i.e. chemical toxicity and solubility, its persistence in the environment, biodegradability and potential for bioaccumulation); the volume spilled; the source of the spill relative to the surface (e.g. subsurface or at surface); sea state; weather conditions and wind direction, the speed and effectiveness of spill response; and the sensitivity of receptors affected. Consequently, it is not possible to produce a single impact assessment of the significance of adverse effects as there are a large number of possible permutations and each spill has the potential to be different to another. Chemical spills will be reduced or avoided through the removal of all redundant chemicals from Brae installations as part of topside preparation, flushing and cleaning all process equipment to appropriate standards, and providing spill kits for dealing with spill incidents.

The volumes of chemicals present during decommissioning will be low compared to the volumes present during the operational phase, as chemicals will have been removed following cessation of production (COP) and handled according to existing permits and in compliance with relevant legislation. As a result, the maximum volume that could potentially be spilled will be low. Therefore as the magnitude of any spill would be low it would be likely to be diluted and disperse rapidly in the sea.

IMPACTS TO BIOLOGICAL RECEPTORS

Biological receptors for chemical spills are the same as those described above for hydrocarbon spills. The mechanism of potential impact may vary dependent on the composition of the chemical released. Effects are anticipated to be short term and localised with a risk of toxicity to plankton, fish, marine mammals or birds.

IMPACTS TO SOCIO-ECONOMIC RECEPTORS

Socio-economic receptors for chemical spills are the same as those described above for hydrocarbon spills, with exclusion effects, particularly affecting commercial fisheries as discussed above. Effects are anticipated to be short term with localised impact to commercial fisheries.

Potential Impacts: Dropped Objects

Potential Sources of Dropped Objects

Potential exists for physical objects associated with decommissioning to be dropped into the sea during decommissioning works. These could range from small hand tools up to large sections of topsides or jackets if there is a major unexpected issue for example during cutting of sections or a crane lift.

Whilst small items such as tools are unlikely to result in any significant adverse effects, larger items, once on the seabed could present snagging hazards to fishing vessels. A large dropped object in the vicinity of the Brae Area cuttings piles may also cause disturbance of cuttings piles sediment resulting in mobilisation of associated pollution. Localised impacts on benthic communities may also occur directly as a result of crushing, or as a result of smothering as mobilised seabed sediment settles back out.

Impact Assessment

The worst case scenario is likely to be a large object being dropped which impacts a cuttings pile, disturbing the cuttings and mobilising any contamination. This would cause localised disturbance to the

seabed, although it is anticipated that cuttings would re-settle quickly under gravity but may be spread over a wider area than the current cuttings pile, and could therefore cause smothering effects to benthic communities not currently affected. Based on the assumptions made regarding settlement of sediment in TA 5.2: Seabed Disturbance Effects, it is anticipated that the maximum lateral extent of effect would be 130 m, with sediment settling within 9 mins of the initial disturbance. On this basis, effects would be contained within an area of the seabed in close proximity to the subsea installations and jacket/sub-structures. This part of the seabed contains a significant amount of subsea infrastructure in the form of pipelines, flowlines, umbilicals, cables and mattress protection structures, and therefore the benthos is not considered to be of high sensitivity. Effects on burrowing seabed fauna e.g. Nethrops are not likely to be significant.

There is a risk in this area that dropped objects could damage to pipelines, flowlines and umbilicals left in place on the seabed. Appropriate flushing and cleaning would have taken place prior to the operations that would carry a risk of dropped objects. On this basis, any residual contamination in the infrastructure would be present in small quantities and would subject to high rates of dilution. Impacts to water quality would also be localised and temporary.

Laboratory testing (see Chapter 3: Environmental Baseline) indicated that, if leached from drill cuttings piles, THC and PAH are unlikely to adversely affect water quality. While the laboratory tests indicated the potential for APEs to have a negative impact on water quality, it is noted that laboratory leaching test results are likely to overestimate leaching rates due to the exaggerated exposure of the sediment to water and the aggressive nature of the tests. Overall the studies undertaken for the Brae Area drill cuttings piles indicate a low potential for significant leaching of contaminants from newly exposed areas of cuttings. Effects on fish species would be localised and short term, with the majority of fish likely to have left the immediate area during the decommissioning activities as a result of deterrent effects associated subsea activities.

IMPACTS TO SOCIO-ECONOMIC RECEPTORS

As described above, the main potential impact on fish is the temporary effects on water quality or localised benthic habitat smothering as a result of the redistribution of drill cuttings pile sediments following a dropped object disturbing a drill cuttings pile. However it is noted that neither is considered likely to have a significant socio-economic effect. It is noted that commercial fishing is currently excluded from the zone around the Brae Alpha and Bravo platforms for safety reasons. Safety zones would not be revised until following the completion of decommissioning activities.

Any large dropped objects would be recovered to the surface, consequently no long term snagging hazards to commercial fishing nets is anticipated.

Environmental Management Controls

Mitigation of any effects from accidental events primarily seeks to avoid accidental events from occurring. Secondary mitigation seeks to ensure a rapid, robust and effective response to any leaks or spills after they have occurred in order to minimise the magnitude of any impact event, and therefore the significance of any resultant effect on sensitive receptors.

Hydrocarbon Spills

In order to reduce the likelihood of a significant hydrocarbon leak or spill occurring, Marathon Oil undertakes to:

- flush and clean all process equipment to appropriate standards; and

- complete and implement decommissioning OPEPs for all installations.

Chemical Spills

In order to reduce the likelihood of a significant chemical leak or spill occurring, Marathon Oil will:

- remove all redundant chemicals from Brae installations as part of topside preparation;
- flush and clean all process equipment to appropriate standards; and
- implement procedures for chemical spill prevention and provide spill kits for dealing with spill incidents.

Dropped Objects

During the decommissioning works all reasonable care will be taken by Marathon Oil and their contractors to avoid dropped objects; this will principally be achieved through work method statements setting out the proposed decommissioning methodology and control measures to prevent dropped objects that will be subject to review by Marathon Oil before work begins.

Following completion of the decommissioning works a seabed survey will be undertaken in order to identify any dropped objects and any items (other than those intended to be left on the seabed) that are considered to have the potential to present hazards will be recovered to the surface and removed. The locations of any objects that are left on the seabed will be communicated to the UK Hydrographic Office and added to FishSafe so that this information can be made available to other sea users through charts and the FishSafe system.

Technical Appendix 5.1: Underwater Noise Impact Assessment

Introduction

This Technical Appendix (TA) provides additional information in support of the assessment of potentially significant effects of underwater noise as summarised within ES Chapter 5: Summary of Environmental Effects. Data provided within this TA specifically supports the ES conclusions relating to:

- Decommissioning of Jacket / Sub-structures and Subsea Installations (ES section 5.3); and
- Decommissioning of pipelines (ES section 5.4).

Specifically this TA covers the potential for significant underwater noise effects associated with cutting activities required for the removal structures and installations.

Underwater Noise Modelling Methodology

The decommissioning of the Brae Area will generate underwater sound that can potentially result in environmental impact to marine life. An underwater noise propagation study and noise mapping has been performed to be used to assess the potential environmental impacts on marine mammals for the proposed decommissioning process.

Underwater Noise Sources

Based on the impact threshold limits and knowledge of the underwater noise sources and respective levels, the potentially significant underwater noise sources as part of the decommissioning have been identified as underwater cutting.

Underwater noise source levels and frequency data, have been collected, analysed and corrected to be applicable for each specific activity.

Each noise source's activity length (time) has been determined in order to predict the cumulative, average and the maximum noise levels/maps. Applicable underwater sound parameters for the assessment of potential impacts on marine mammal species have been defined with reference to published literature and agreed through consultation with the JNCC.

Underwater Noise Modelling Positions and Planned Activities

The following activities and positions have been modelled for underwater noise.

- Underwater cutting: Brae Alpha platform, Latitude N 58º 41′ 33.05" Longitude E 001º 16′ 54.07"
- Underwater cutting: Brae Bravo platform, Latitude N 58º 47′ 32.510" Longitude E 01º 20′ 50.639"'

Underwater Sound

Sound travels at different speed in different media. The speed of sound is determined by the density and compressibility of the medium. Density is the amount of material in a given volume, and compressibility is a measure of how much a substance could be compacted for a given pressure. The denser and the more compressible, the slower the sound waves would travel. Water is much denser than air, but since it is nearly incompressible the speed of sound is about four times faster in water than in air. The speed of sound can also be affected by temperature. Sound waves tend to travel faster at higher temperatures.

Underwater sound can be measured as a change in pressure and is described as sound pressure and can be measured with a pressure sensitive device (hydrophone).

Because of the large range pressure amplitudes of sound, it is convenient to use a decibel (dB) logarithmic scale to quantify pressure levels. The underwater sound pressure level in decibels (dB) is defined in the following equation:

- Sound Pressure Level (SPL) = 20log10(P/P0)

P is the pressure and P0 is the reference pressure. The reference pressure is 1 microPascal (µPa) for underwater sound which is different for sound pressure levels in the air.

Underwater sound levels vary in accordance to the sound source's time signature and acoustic environmental conditions and can be future defined in terms of exposure, average and/or maximum levels. The following acoustic parameters are commonly used to assess the noise impact from underwater noise sources for the identified local marine life.

Marine Mammal Frequency Weighting

The potential for underwater noise to impact marine species depends on how well the species can hear the sounds produced [1]. Noises are less likely to disturb or injure animals if they are at frequencies outside the animals' hearing range. For non-injurious sound levels, frequency weighting based on audiograms may be applied to weight the importance of sound levels at particular frequencies in a manner reflective of the receiver's sensitivity to those frequencies [13],[14].

Based on a review of literature on marine mammal hearing and on physiological and behavioural responses to anthropogenic sound, Southall [1] proposed standard marine mammal frequency weighting (M-weighting) functions for various functional hearing groups of marine mammals (see Table TA 5.1.1):

- Low-frequency cetaceans (LFCs) - mysticetes (baleen whales);
- Mid-frequency cetaceans (MFCs) - some odontocetes (toothed whales);
- High-frequency cetaceans (HFCs) - odontocetes specialized for using high-frequencies;
- Pinnipeds in water - seals, sea lions and walrus.

Table TA 5.1.1: Functional hearing groups and associated auditory bandwidths

Functional hearing group	Relevant species	Estimated auditory bandwidth	Frequency-weighting network
Pinnipeds in water	Grey seal and harbour seal	75 Hz to 22 kHz	M_{pw}
High frequency cetaceans	Harbour porpoise (*Phocoena phocoena*)	200 Hz to 180 kHz	M_{hf}
Mid-frequency cetaceans	Long-finned pilot whale (*Globicephala melas*), Killer whale (*Orcinus orca*), Risso's dolphin (*Grumpus griseus*), White-beaked dolphin (*Lagenorhynchus albirostis*), Atlantic	150 Hz to 160 kHz	M_{mf}

Table TA 5.1.1: Functional hearing groups and associated auditory bandwidths

Functional hearing group	Relevant species	Estimated auditory bandwidth	Frequency-weighting network
	white-sided dolphin (*Lagenorhynchus actus*)		
Low-frequency cetaceans	Minke whale (*Balaenoptera acutorostrata*)	7 Hz to 22 kHz	M_{lf}

Potential Impacts on Marine Mammals from Underwater Noise

The potential direct impacts of noise on marine mammals can be divided into four broad categories that largely depend on the individual's proximity to the sound source. As illustrated by Figure 5.1.1, there are four categories:

- Detection (audibility), is where the animal can sense the noise. Detection ranges depend on background noise levels as well as hearing criteria for the animals in question.
- Masking is an impact where repeated or long-term underwater noise disturbs e.g. communication between individuals. The masking noise must be audible, roughly coincide with, and have energy in roughly the same frequency band as the masked sound. The zone of audibility can be used as a very precautionary indicator to the possible extent of the zone of masking.
- Behavioural response (responsiveness) ranges from very strong reactions, such as panic or flight, to more moderate reactions where the animal may orient itself towards the sound or move slowly away. However, the animals' reaction may vary greatly depending on season, behavioural state, age, sex, as well as the intensity, frequency and time structure of the sound causing behavioural changes.
- Physical damage relates to damage to the hearing apparatus of the marine mammals. Physical damage to the hearing apparatus may lead to permanent changes in the animals' detection criteria (permanent threshold shift, PTS). This can be caused by the destruction of sensory cells in the inner ear, or by metabolic exhaustion of sensory cells, support cells or auditory nerve cells. Hearing loss is usually only temporary (temporary threshold shift, TTS) and the animal will regain its original detection abilities after a recovery period. For PTS and TTS the sound intensity is an important factor for the degree of hearing loss, as is the frequency, the exposure duration, and the length of the recovery time.

The limits of each zone of impact are not sharp and there is a large overlap between the zones.

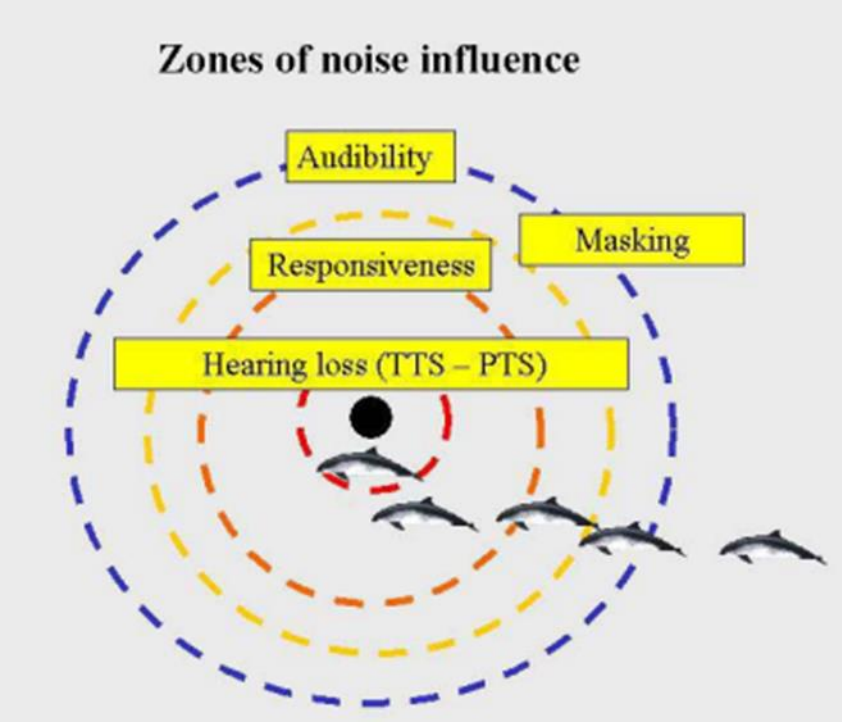

Figure 5.1.11 Visual representation of the four zones of underwater noise influence.

Legislative protection for Marine Mammals receptors from effects of Underwater Noise

Seals are designated in a number of UK Natura 2000 sites. In addition, under the Marine (Scotland) Act 2010, it is an offence to kill, injure or take a seal at any time of year (except to alleviate suffering or where a licence has been issued to do so by Marine Scotland), and it is an offence to intentionally or recklessly harass seals at significant haul-out sites, when these sites have been designated. The EC Habitats Directive (as transposed into UK and Scottish law in the 'habitats regulations [15]) also prohibits certain methods of catching or killing seals.

Cetaceans (whales, dolphins and porpoises) are also designated in a number of UK Natura 2000 sites, and are also a strictly protected species (European Protected Species, EPS [16]) under the habitats regulations. It is an offence to intentionally or recklessly kill, injure, capture, disturb and harass EPS. In addition, cetaceans are covered by a number of international agreements and conventions, e.g. Agreement on the Conservation of Small Cetaceans in the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS), the Convention on Biological Diversity (CBD) and the Convention on the Conservation of Migratory Species of Wild Animals [17].

In accordance with the methodology (the sensitivity of seals and cetaceans to injury and PTS is assessed to be "high". The sensitivity of seals and cetaceans to TTS and behavioural impact is assessed to be "medium".

Underwater Sound Propagation Model

The underwater sound propagation model calculates estimates of the sound field generated from underwater sound sources. The modelling results are used to determine the potential impacts distances (noise maps/contour plots) from the identified significant underwater noise sources for the various identified marine life for the area. Based on source location and underwater source sound level, the acoustic field at any range from the source is estimated using dBSEA's acoustic propagation model

(Parabolic equation method (≤500 Hz), and ray tracing (> 500 Hz)) [11]. The sound propagation modelling uses acoustic parameters appropriate for the specific geographic region of interest, including the expected water column sound speed profile, the bathymetry, and the bottom geo-acoustic properties, to produce site-specific estimates of the radiated noise field as a function of range and depth. The acoustic model is used to predict the directional transmission loss from source locations corresponding to receiver locations. The received level at any 3-dimensional location away from the source is calculated by combining the source level and transmission loss, both of which are direction dependent. Underwater acoustic transmission loss and received underwater sound levels are a function of depth, range, bearing, and environmental properties. The output values can be used to compute or estimate specific noise metrics relevant to safety criteria filtering for frequency-dependent marine mammal hearing capabilities.

Underwater sound source levels are used as input for the underwater sound propagation program, which computes the sound field as a function of range, depth, and bearing relative to the source location.

The model assumes that outgoing energy dominates over scattered energy, and computes the solution for the outgoing wave equation. An approximation is used to provide two-dimensional transmission loss values in range and depth, i.e., computation of the transmission loss as a function of range and depth within a given radial plane is carried out independently of neighbouring radials (reflecting the assumption that sound propagation is predominantly away from the source).

The received underwater sound levels at any location within the region of interest are computed from the 1/1-octave band source levels by subtracting the numerically modelled transmission loss at each 1/1-octave band centre frequency and summing across all frequencies to obtain a broadband value. For this study, transmission loss and received levels were modelled for 1/1-octave frequency bands between 10 and 3000 Hz. Because the source of underwater noise considered in this study are predominantly low-frequency sources, this frequency range is sufficient to capture essentially all of the energy output. The received levels are converted to all the applicable underwater acoustic parameters.

Predictions have been performed for both winter and summer water column conditions which have different underwater sound propagation characteristics and will show the maximum underwater noise level of the whole sea depth.

The sound propagation model has been developed to provide Peak, RMS, SEL, SELcumulative (2 hour) for the various scenarios, source levels, activity time and environmental parameterisation. The model is used to generate noise maps. The levels depicted in the noise maps is the maximum predicted level for that location at any depth down to the bottom and includes the following acoustic parameters for each of the identified significant sound sources:

For under water cutting:

- SEL, 2 hour and 24 hour Cumulative Sound Exposure Level (linear), dB re. 1µPa., 1 sec.
- SPL, RMS levels (linear), dB re. 1µPa.

The results of the acoustic modelling (noise maps and impact distances) are reported in terms of the underwater sound levels of each specific acoustic metric for distances up to 200 km. In addition, a vertical sound propagation profile plot for the dominant sound source frequency band has been generated to show the variation in underwater sound propagation with regards to sea depth.

Marine Mammal Fleeing Factor

Due to the fact that marine mammals will move away from high underwater noise sources thereby reducing its overall exposure level for continuous underwater noise sources relative to if the animal was stationary, the calculations have been performed for both a stationary (24 hour) and 'flee factor' corrected (2 hour) underwater noise exposure. Cumulative exposure over 24 hours is a greatly overestimated impact, whereas exposure over 2 hours is believed to be realistic including movement and fleeing.

Underwater Sound Source Levels

In order to obtain an equivalent source level at 1 m from the source, for the purpose of acoustic propagation modelling, the source levels were back-propagated to the pressure field according to cylindrical spreading loss, or 15·log(r). The purpose of the back-propagation step is to determine the effective source level at 1 m that is used in the acoustic propagation model.

The following table shows the estimated overall underwater sound source levels.

Table TA 5.1.2: Underwater cutting

Activity	Sound source pressure level at 1 meter		
	RMS, dB re. 1µPa	Peak, dB re. 1µPa	SEL, dB re. 1µPa2/s
Underwater cutting	195	198	244 (Cumulative 24 hr)

The frequency spectrum used for underwater cutting was more high frequency (2-3 kHz) based on measurement data from jet cutting.

Bathymetry

The relief of the sea floor is an important parameter affecting the propagation of underwater sound, and detailed bathymetric data are therefore essential to accurate modelling.

A base-level-resolution bathymetric dataset for the entire study area was obtained from public from the EMODnet data portal [18].

Seabed layer information was gathered from the EDOMNET data for areas close to the modelling positons and used in the modelling [19].

Table TA 5.1.3: Overview of seabed geo-acoustic profile used for the modelling(Cp = compressed wave speed, α = compressional attenuation

Seabed layer (m)	Material	Geoacoustic property
0 – 10 meters	Deep Sea Mud	Cp = 1500 m/s

α = 0,2 dB/λ

Sound Speed Profiles

Water column data (Salinity, temperature/depth) is provided from ICES (International Council for the Exploration of the Sea) HELCOM specific measurement stations positioned close to the selected modelling positions. This data is used to calculate the sound speed profile for the modelling positions

and used as input in the underwater sound propagation model. (http://ocean.ices.dk/HydChem/HydChem.aspx?plot=yes)

Predictions have been performed for both winter and summer water column conditions which have different underwater sound propagation characteristics.

Modelling Output

The sound propagation model uses the model scenarios - Peak, RMS, SEL, SELcumulative, source levels, activity time and environmental parameterisation to generate noise maps. The levels depicted in the noise maps are the maximum predicted level for that location at any depth down to the bottom and include the following acoustic parameters for each of the identified significant sound sources.

- For cutting:
  - 24 hour stationary, M weighted SEL, Cumulative Sound Exposure Level (linear), dB re. 1µPa., 1 sec.
  - 2 hour fleeing/movement, M weighted SEL, Cumulative Sound Exposure Level (linear), dB re. 1µPa., 1 sec.
  - SPL, RMS levels (linear), dB re. 1µPa.
  - PEAK: Peak levels (linear), dB dB re. 1µPa.

Impact Assessment Methodology

Introduction

The area of interest is within the Brae Area, which is approximately 270 km northeast of Aberdeen, on the edge of the Fladen Scottish sea area of the northern UK sector of the North Sea. A full description of the scope of the Decommissioning Programme is provided in Chapter 2 of this ES.

Activities to be Assessed

The following parameters have been used within this assessment:

- For the partial removal of the Brae Alpha substructure using a Heavy Lift Vessel (HLV) to recover the substructure in sections, the removal activities are anticipated to take between 48-64 days, with the cutting operations expected to last 38-42 days.
- For the partial removal of the Brae Bravo substructure the removal activities using an HLV would vary from 35-53 days, with the cutting operations expected to last from 28-32 days.
- For a single lift operation, the cutting activities would be expected to last four days for both Brae Alpha and Brae Bravo.

Similar cutting activities of varying durations may be required as part of the decommissioning activities at Central Brae, West Brae and Sedwick where cutting to remove subsea installations is required.

Sensitivity Criteria

Impact assessment criteria for assessing the sensitivity of the receiving environment/feature are summarised in Table TA 5.1.4.

Table TA 5.1.4: Criteria for assessing the sensitivity of the receiving environment/receptors

Criteria	Description
High	The habitat/species/feature holds international conservation value or legal protection. The feature is not able to tolerate changes and will be completely lost as a result. The feature has no means of adaption to change. The feature will take >25 years to return to baseline conditions or normal function.
Medium	The habitat/species/feature holds national conservation value or legal protection. The feature has limited ability to tolerate changes and will be severely damaged. The feature has limited ability to adapt to change e.g. limited mobility. The feature may recover fully in 10 to 25 years.
Low	Widespread habitat/species/feature, regional conservation importance, plays a key ecosystem role. The feature can tolerate a small degree of change but may experience damage. The feature can adapt or avoid changes. The feature may recover fully in five to ten years.
Negligible	Widespread habitat/species/feature, no conservation importance or key ecosystem role. The feature is tolerant to the changes and is unlikely to be damaged. The feature is full able to avoid changes e.g. full perception and mobility. The feature may recover in less than five years.

Magnitude of Effect

Impact assessment criteria for assessing the magnitude of effect to the receiving environment/receptors are summarised in Table TA 5.1.5.

Table TA 5.1.5: Criteria for assessing the magnitude of the receiving environment/receptors

Criteria	Description
Large	Effect apparent over twenty km from the source or covering a large proportion to all of habitat contributing to the function of the feature. Effect will continue to persist and occur regularly after the decommissioning works are complete. Effects will exceed recommended thresholds in all cases (where applicable).
Medium	Effect apparent up to twenty km from the source or covering a notable proportion of habitat contributing to the function of the feature. Effect will continue to occur intermittently after the decommissioning works are complete. Effects will exceed recommended thresholds in most cases (where applicable).
Small	Effect apparent up to ten km from the source or covering a small area of habitat contributing to the function of the feature. Effect will occur regularly throughout the decommissioning works and be apparent for less than a week. Effect will be observable against background variation, but below thresholds (where applicable).
Negligible/ None	Effect apparent within one km of the source or covering a no areas of habitat contributing to the function of the feature. Effect is likely to last less than a day and be intermittent though the decommissioning works only. Effect is unlikely to exceed conditions observed as part of natural variation.

In this instance, these have been supplemented with specific criteria relating to the auditory range within which marine mammals may be affected by underwater noise. Relevant criteria for non-pulse 24 hour jet cutting (Table TA 5.1.6) and non-pulse 2 hour jet cutting (Table TA 5.1.7). The criteria are associated with different impacts: Permanent Threshold Shift (PTS), Temporary Threshold Shift (TTS) and behavioural response.

Table TA 5.1.6: Criteria for marine mammals exposed to underwater noise from non-pulse 24 hour jet cutting

Functional Hearing Group	Relevant Species	Auditory Bandwidth	Frequency-weighting network	Criteria for 24h jet cutting (non-pulse)		
				PTS (Lp (SPL))	TTS (Lae (SEL))	behavioural response (Lp (SPL))
Pinnipeds in water	grey seal and harbour seal	75 Hz to 22 kHz	M_{pw}	218 dB re: 1µPa	203 dB re: 1µPa2-s	212 dB re: 1µPa
High Frequency	Harbour porpoise (*Phocoena phocoena*)	200 Hz to 180 kHz	M_{hf}	230 dB re: 1µPa	215 dB re: 1µPa2-s	224 dB re: 1µPa
Mid-Frequency	Long-finned pilot whale (*Globicephala melas*), Killer whale (*Orcinus orca*), Risso's dolphin (*Grumpus griseus*), White-beaked dolphin (*Lagenorhynchus albirostis*), Atlantic white-sided dolphin (*Lagenorhynchus actus*)	150 Hz to 160 kHz	M_{mf}	230 dB re: 1µPa	215 dB re: 1µPa2-s	224 dB re: 1µPa
Low-Frequency	Minke whale (*Balaenoptera acutorostrata*)	7 Hz to 22 kHz	M_{lf}	230 dB re: 1µPa	215 dB re: 1µPa2-s	224 dB re: 1µPa

”cum” refers to the cumulative SEL.

rms SPL: root mean square Sound Pressure Level.

SEL: Sound Exposure Level.

*Note that two references (1 and 3) apply SEL m-weighting.

Table TA 5.1.7: Criteria for marine mammals exposed to underwater noise from non-pulse 2 hour jet cutting.

Functional Hearing Group	Relevant Species	Auditory Bandwidth	Frequency-weighting network	Criteria for 2h jet cutting (non-pulse)		
				PTS (Lp (SPL)	TTS (Lae (SEL))	behavioural response (Lp (SPL))
Pinnipeds in water	grey seal and harbour seal	75 Hz to 22 kHz	M_{pw}	218 dB re: 1µPa	203 dB re: 1µPa2-s	212 dB re: 1µPa
High Frequency	Harbour porpoise (*Phocoena phocoena*)	200 Hz to 180 kHz	M_{hf}	230 dB re: 1µPa	215 dB re: 1µPa2-s	224 dB re: 1µPa
Mid-Frequency	Long-finned pilot whale (*Globicephala melas*), Killer whale (*Orcinus orca*), Risso's dolphin (*Grumpus griseus*), White-beaked dolphin (*Lagenorhynchus albirostis*), Atlantic white-sided dolphin (*Lagenorhynchus actus*)	150 Hz to 160 kHz	M_{mf}	230 dB re: 1µPa	215 dB re: 1µPa2-s	224 dB re: 1µPa
Low-Frequency	Minke whale (*Balaenoptera acutorostrata*)	7 Hz to 22 kHz	M_{lf}	230 dB re: 1µPa	215 dB re: 1µPa2-s	224 dB re: 1µPa

"cum" refers to the cumulative SEL.

rms SPL: root mean square Sound Pressure Level.

SEL: Sound Exposure Level.

*Note that two references (1 and 3) apply SEL m-weighting.

Significance Criteria

The assessment of residual environmental effects identifies the likely significant effects associated with the decommissioning following the implementation of committed mitigation measures. Significance relies on accepted thresholds and criteria where available, or, for situations in which such are not available, expert interpretations and value judgments.

The significance of each effect can be identified based on the matrix and categories described in Table TA 5.1.8.

Table TA 5.1.8: Assessment of the significance of residual environmental effects, based on magnitude and sensitivity.

		Sensitivity of receptor			
		Negligible	**Low**	**Medium**	**High**
Magnitude of effect	No or negligible	Negligible	Minor	Minor	Moderate
	Low	Minor	Minor	Moderate	Moderate
	Medium	Minor	Moderate	Moderate	Major
	High	Moderate	Moderate	Major	Major

- 'Impact' requiring mitigation

Where likely significant effects are identified (moderate or high effects), mitigation measures to reduce their significance to acceptable levels will be described.

Marine Mammal Baseline Data

The primary receptors identified for consideration for significant effect from underwater noise generation are marine mammals. The following section of this TA sets out available, relevant baseline information for marine mammals in the Brae Area.

Marine mammals in the Brae Area include seals (grey seal (*Halichoerus grypus*) and harbour seal *(Phoca vitulina*)), as well as a number of cetaceans. The most commonly sighted cetacean species is the harbour porpoise (*Phocoena phocoena*), though Atlantic white-sided dolphin ((*Lagenorhynchus actus*), white-beaked dolphin (*Lagenorhynchus albirostris*), Risso's dolphin (*Grampus griseus*), killer whale (*Orcinus orca*), minke whale (*Balaenoptera acutorostrata*) and long-finned pilot whale (*Globicephala melas*) are also known to occur in this part of the North Sea [20].

Table TA 5.1.9 provides an overview of the marine mammal species present in the Brae Area and their conservation status. Further detail on species distribution, population estimates, conservation status and biology is provided based on published literature ([21], [17], [22]; [20], [23]; [24]; [25]; [26][28][27],[29]).

Table TA 5.1.9: Overview of marine mammals species which may occur in the Brae Area

Species	Occurrence in Brae Area	IUCN Conservation Status
Minke whale	Least Concern	May occur in low density. Brae Area not a key habitat.
White-beaked dolphin	Least Concern	May occur in low density. Brae Area not a key habitat
Atlantic white-sided dolphin	Least Concern	May occur in low density. Brae Area not a key habitat.
Risso's dolphin	Least Concern	May occur in low density. Brae Area not a key habitat.

Table TA 5.1.9: Overview of marine mammals species which may occur in the Brae Area

Species	Occurrence in Brae Area	IUCN Conservation Status
Killer whale	Date deficient	May occur in low density. Brae Area not a key habitat.
Long-finned pilot whale	Least Concern	May occur in low density. Brae Area not a key habitat.

Grey seal (*Halichoerus grypus*)

Distribution

Grey seals are found in the North Atlantic, the Barents Sea and Baltic Sea. 38% of the global grey seal population lives around the coast of the UK and especially in Scottish coastal waters (88 %). The main Scottish breeding grounds are the Outer Hebrides and the Orkney´s, with smaller breeding colonies found along the UK coastline and on Shetland [26] (see Figure 5.1.2).

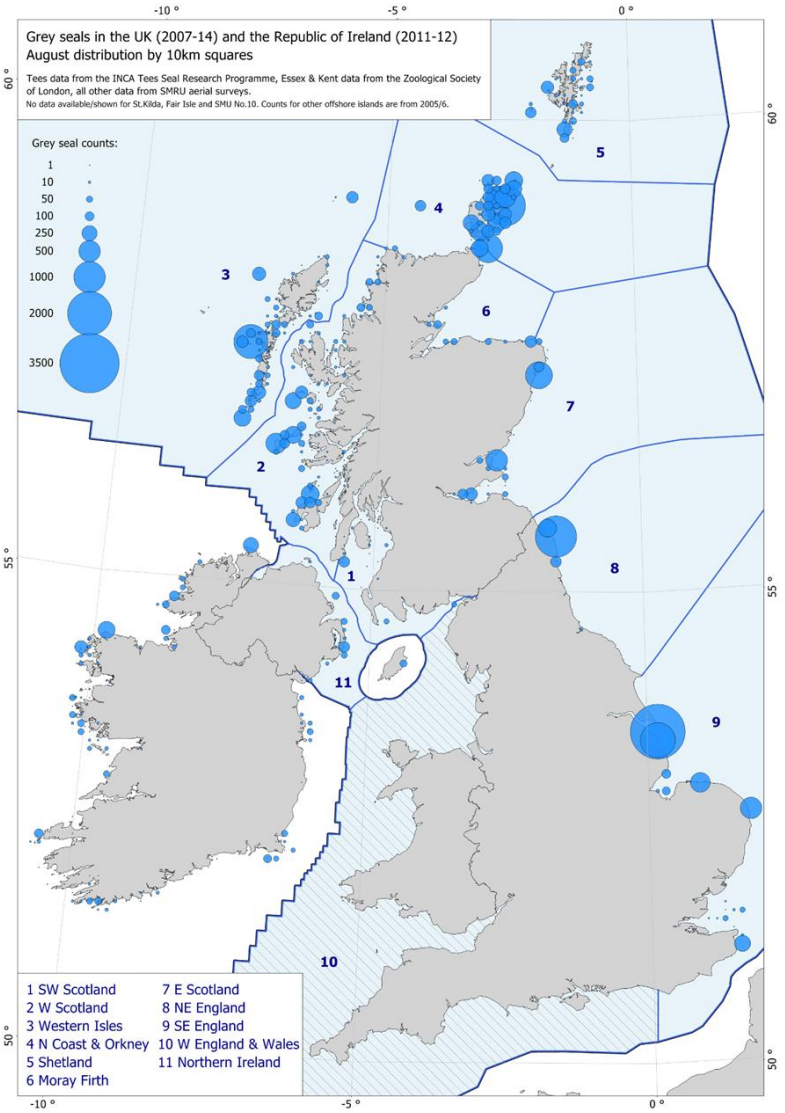

Figure 5.1.2: Grey seal colonies and estimated abundance in the United Kingdom [26].

IUCN Status

The grey seal was assessed as 'Least Concern' in 2008. Most populations have increased over the last 30 years and reflect a robust population, able to withstand culling and increased interspecific competition (e.g. from other seal species) [22].

Biology

Grey seals typically breed on remote uninhabited islands or rocky coast and caves. Though shy when on land, some breeding colonies can habituate to human activities. Grey seals feed in the open sea, at up to 100 meters depth, and regularly return to land for resting, moulting and breeding. The species frequently travel 100 km between haul-out sites but has preferences to certain regions. There has been observed movement between haul-out sites in the North Sea and the Outer Hebrides. Grey seals in the UK spend longer hauled out during their annual moult (between December and April) and during their breeding season (between August and December). In north and west Scotland the pupping normally occurs in September to late November. The pup needs to shed its fur to become waterproof, shedding lasts 4-5 weeks and in this period the pup cannot enter the water [21].

Hearing

The hearing of grey seals has only been investigated in a single study [28]. The general assumption is that the hearing abilities of harbour and grey seals are very similar, and reference is made to the audiogram presented for harbour seal for the purposes of this assessment (Figure 5.1.4).

Harbour seal (*Phoca vitulina*)

Distribution

The harbour seal or common seal is found circumpolar in the northern hemisphere and is the most wide-spread species of pinniped. The European sub-species *Phoca vitulina vitulina*, are found from northern France in the south, to Iceland in the west, Svalbard in the North and the Baltic Sea in the east and with the largest population in the Wadden Sea [20] . Figure 5.1.3 illustrates the distribution of harbour seal around the UK and Ireland.

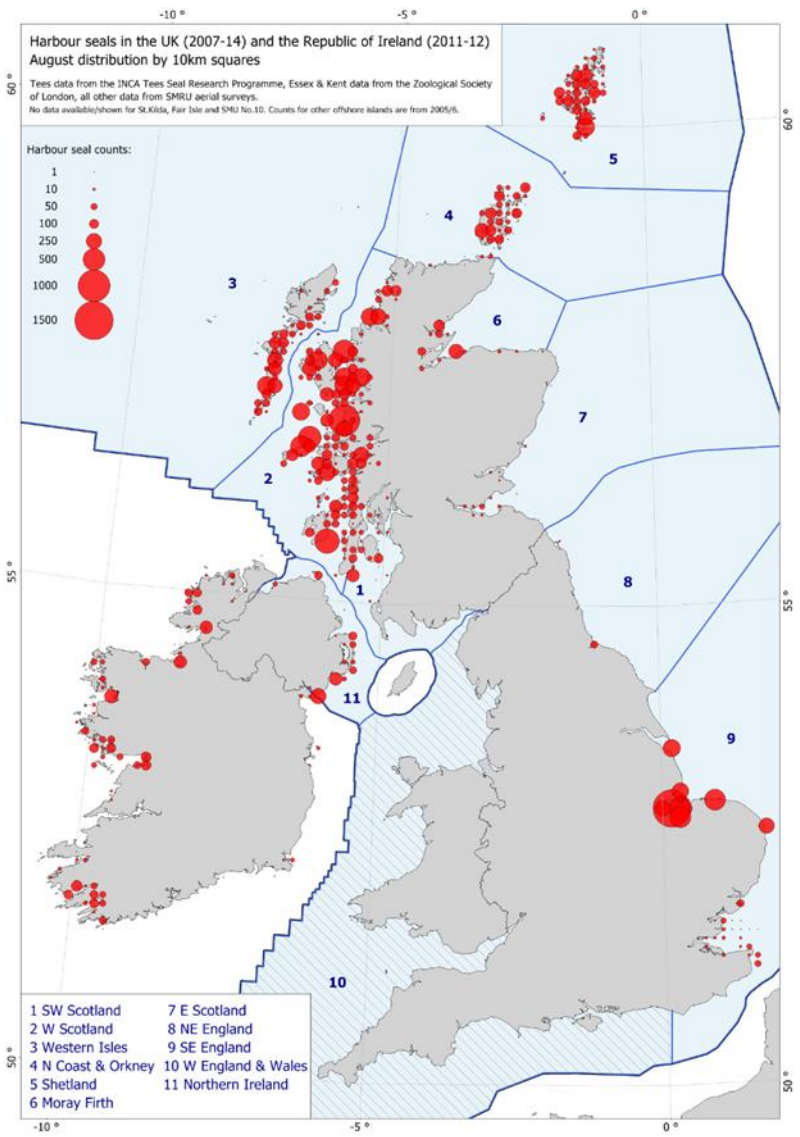

Figure 5.1.3: Harbour seal colony distribution and estimated abundance in the United Kingdom [26]. Harbour seals are counted while they are on land during their August moult, giving a minimum estimate of population size.

Population Estimate/Size of Population

The global population size is estimated to be 350,000-500,000 individuals. National counts in the UK from 2007-2014 estimated the 2014 population to be 40,414 individuals (95% C.L. 33,106 – 55,029). The Natural Environment Research Council (NERC) appointed Special Committee on Seals (SCOS) reports that approximately 30% of the European harbour seal population is found in the UK, with Scottish waters accounting for approximately 79% of the UK population [29].

The European population size is stable or increasing, but has experienced recent population crashes due to disease-outbreaks in the Wadden Sea, South England, Kattegat and Skagerrak.

A decline has been observed in the populations between 2000 and 2014, with the decrease ranging from 30% (Shetland, 2009 - 2009) to 78% (Orkney, 2000 - 2013) and 96% (Firth of Tay, 2000 - 2014). Other populations, mainly on the west coast (West Highlands/ Outer Hebrides) and the English east coast have been largely stable. Possible reasons for the decline are cited as the increased competition and/or direct predation on pups from the grey seal, and blooms of toxic algae.

IUCN Status

On a global scale, harbour seals are listed as 'Least Concern', with few exceptions towards sub-species populations on a local scale (assessed in 2008).

Biology

Harbour seals are mainly found in continental shelf waters; bays, estuaries and tidal zone with high concentrations at their haul out sites (breading, moulting and resting areas). Harbour seals come ashore in sheltered waters, typically on sandbanks and in estuaries, but also in rocky areas. They give birth to their pups in June and July and moult in August. Harbour seals spend a large amount of their time on land (25%) resting, moulting and giving birth. The pups are born in the summer and are well developed capable to dive after few hours. The lactation period last for 4-6 weeks and occurs on land.

Hearing

Seals have amphibious hearing as they can hear both in water and in air. The hearing of harbour seals has been studied extensively. In Figure 5.1.4 an audiogram for harbour seal is presented. Seals communicate vocally by use of a broad bandwidth of sounds with an auditory bandwidth from 75 Hz to 75 kHz (in water), having the highest sensitivities between 1 kHz and 50 kHz.

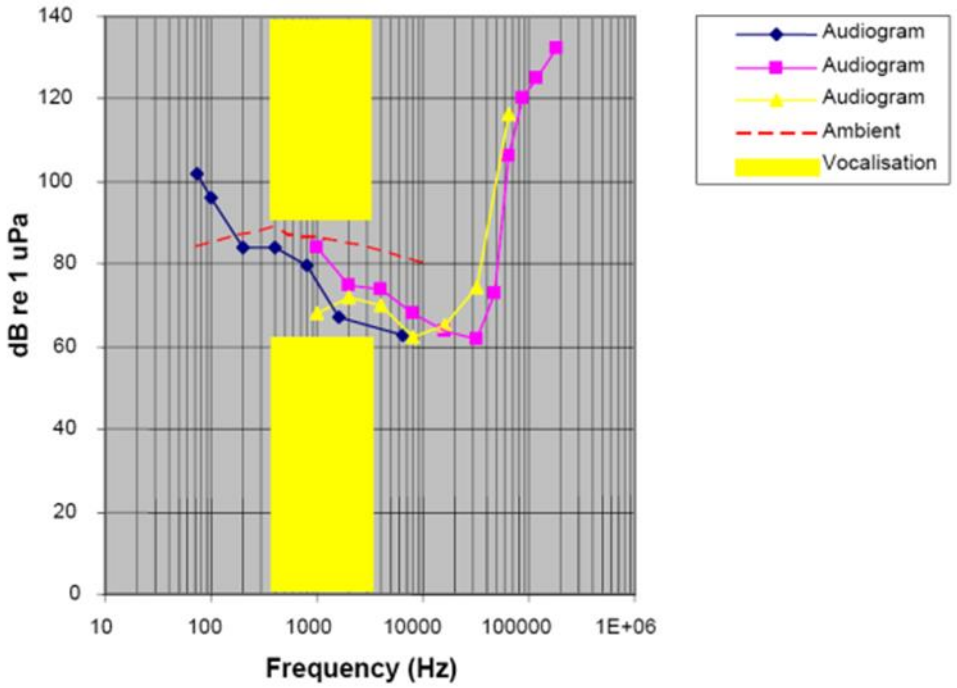

Figure 5.1.4: Audiograms for harbour seal (*Phoca vitulina*) based on [24], [25] and [23]

Harbour Porpoise (*Phocoena phocoena*)

Distribution

Harbour porpoise is widely distributed in temperate waters, North Pacific and North Atlantic, normally around the continental shelf waters, normally hunting in the upper 60 meters of the water column (the maximum recorded dive depth is 220 meter). Harbour porpoise can cross oceans or regions in search for better prey abundance [17]; [26].

Population Estimate

In the European Atlantic, the abundance in 2005 was estimated at 385,600 individuals (an increase from estimated 341,000 individuals in 1994), of which about 335,000 were estimated in the North Sea and adjacent waters [20]. In connection with the SCANS-II project [27] the species was sighted in the Brae Area and the estimated abundances were 47,000 individuals, resulting in a density of 0.293 animal km^2 [22] (see Figure 5.1.6).

IUCN Status

The global population is assessed as Least Concern (in 2008) [20] , but several regional subpopulations can be assessed differently. For example, the small subpopulation in the Baltic Sea (~ 600 individuals) were assessed Critical Endangered in 2008 [20] .

Biology

Harbour porpoise typically gives birth in late June and early July [21]. The average pod size of the harbour porpoise consists of the mother, a calf and maybe a younger female. Larger pods >50 individuals have been seen in connection with feeding or migration. Observations suggest that some populations of porpoise do migrate seasonally according to their preferred prey (clupeoids and gadoids) or to avoid ice in the winter months. However the majority of sightings are within 10 km from the coast [26]; [17].

Hearing

Harbour porpoises use echolocation to communicate and orientate themselves in the water, search for prey and detect obstacles and barriers. The signals made for prey detection and navigation are above 100 kHz [1]. The auditory bandwidth for porpoise is between 200 Hz to 180 kHz. An audiogram for harbour porpoise is presented in Figure 5.1.5.

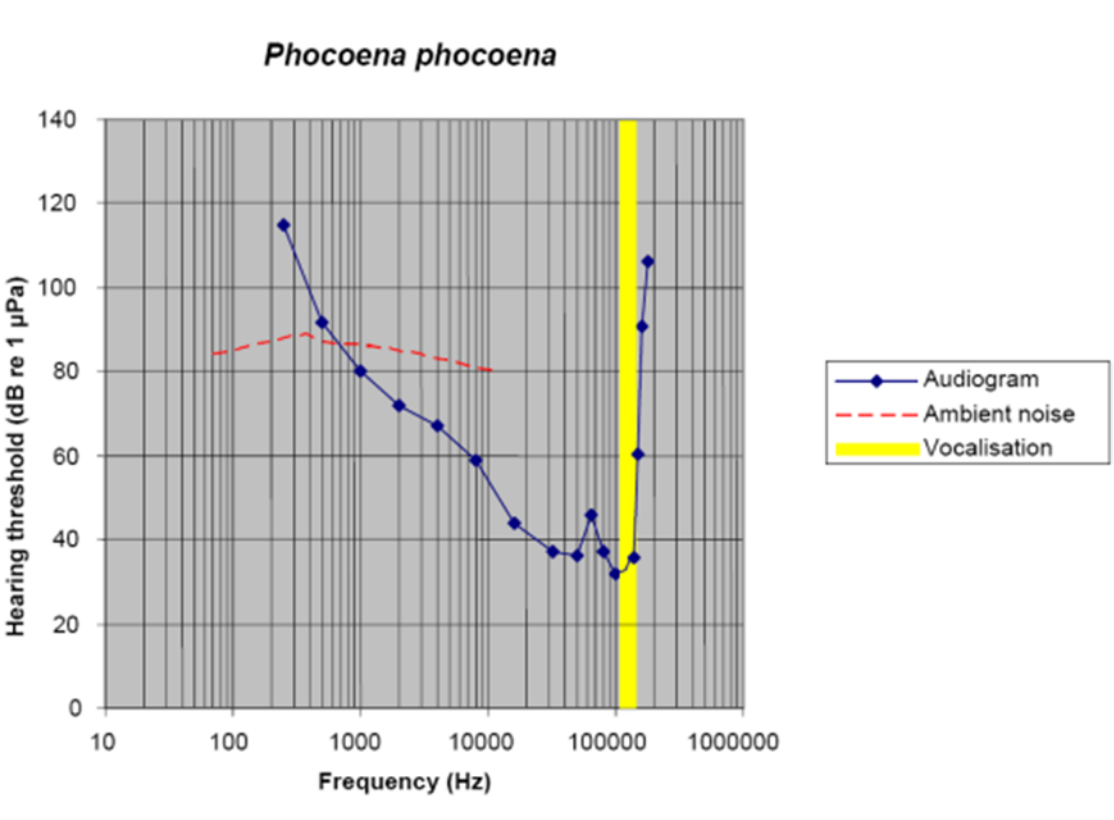

Figure 5.1.5: Audiogram of harbour porpoise (*Phocoena phocoena*). The audiogram shows the hearing threshold. Thus, the best ability to detect sound is at frequencies with the lowest threshold (the best sensitivity). The audiogram also shows an example of ambient noise and the frequency range of harbour porpoise vocalisation [24].

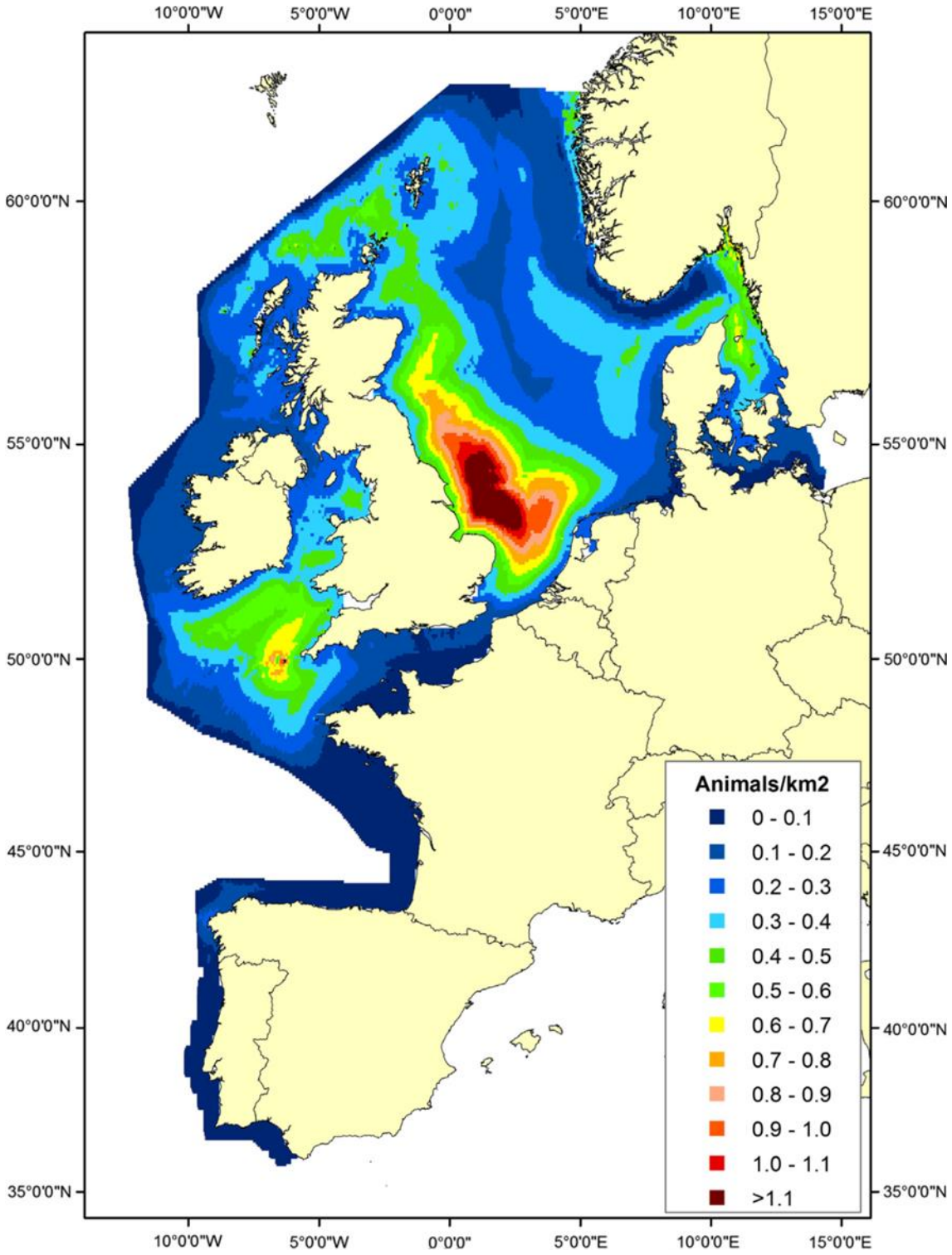

Figure 5.1.6: Harbour porpoise predicted density surface model, based on sighting from the SCANS-II project, presented in the final report from 2006 [27].

Minke Whale (*Balaenoptera acutorostrata*)

Distribution

The minke whale is a cosmopolitan species with observations recorded in both the northern and southern hemisphere. In the Northeast Atlantic region, they are distributed in the south and mid North Sea and off the west coast of Ireland, but there has also been observations as far south as the Mediterranean [17]. The minke whale is mainly observed around the coastal and continental shelf waters

(150-500 meter depth) and in summer some individuals migrate further north to yield from the arctic mid-summer [20] .

Population Estimate

The population in the North Atlantic was estimated to be 181,900 individuals in 2006. The SCANS-I estimated the population in the North Sea, Celtic sea and Skagerrak to be 8,500 in 1994 (95% C.L. 5,000-13,500) [26]. SCANS-II estimated the UK population to be 18,958 (95% C.L. 9,798-36,680) and the abundance in the Brae Area as 4,515 individuals with a density on 0.028 animal km^2 (see Figure 5.1.7) [27].

IUCN Status

The population was assessed as Least Concern in 2008 with a stable population trend [20].

Biology

The minke whale can exploit different types of prey species, both schooling fish, crustaceans and zooplankton [16], which they can hunt in coastal waters or offshore. They form groups ranging from 1-3 individuals, though larger gatherings have been seen in connection with high food concentrations [26]; [17]. The North Atlantic minke whale gives birth to a single calf in early winter, which can happen annually. The mother and the calf often over winter in the southern part of their population range, the UK waters [16].

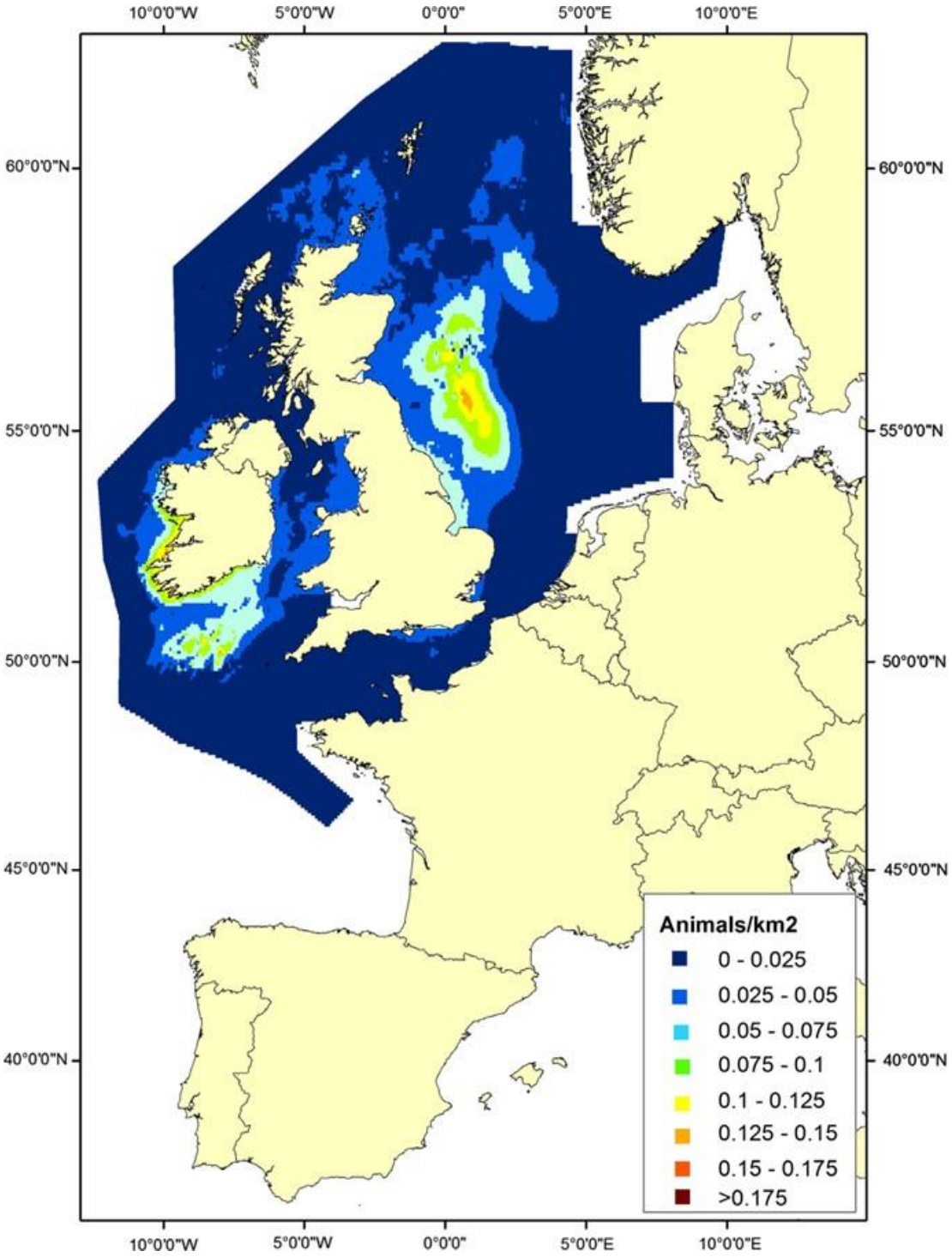

Figure 5.1.7: Minke whales predicted density surface model, based on sighting from the SCANS-II project, presented in the final report from 2006 [27].

White Beaked Dolphin (*Lagenorhynchus albirostris*)

Distribution

The most northern species of the *Lagenorhynchus genus*, the white-beaked dolphin, is present in the North Atlantic region from the coast of Belgium and the Netherlands in south, to the edge of the pack ice in the north [17]. They primarily inhabit waters around 50-200 meters depth (Figure 5.1.8) [26]. The species is estimated to be abundant throughout its range [20].

Population Estimate

The global population of white-beaked dolphin is estimated to exceed 100,000 individuals [20]. In 2005 the population of white-beaked dolphins in UK waters was estimated at 16,536 (95% C.L. 9,245-29,586). This is an increase from 10,600 individuals estimated during the SCANS-I survey in 1994 [27]. In the Brae Area, the abundance was 7,557 individuals with a density of 0.047 animal/km^2 (the second largest in UK waters) [27].

IUCN Status

The population was assessed as Least Concern in 2012 [20].

Biology

White-beaked dolphin are powerful swimmers, feeding on a variety of fish, mainly clupeoids and gadoids [17]. In UK-waters they form pods with an average size of 4-6 individuals, depending on the number of calves [22] and have been seen forming feeding herds alongside other species of cetacean [21]. The species migration patterns are poorly understood, but surveys using photo-identification have shown movement from Skagerrak to the Scottish coasts. Otherwise, white-beaked dolphins seem to be fairly evenly distributed in UK waters (see Figure 5.1.8) [17].

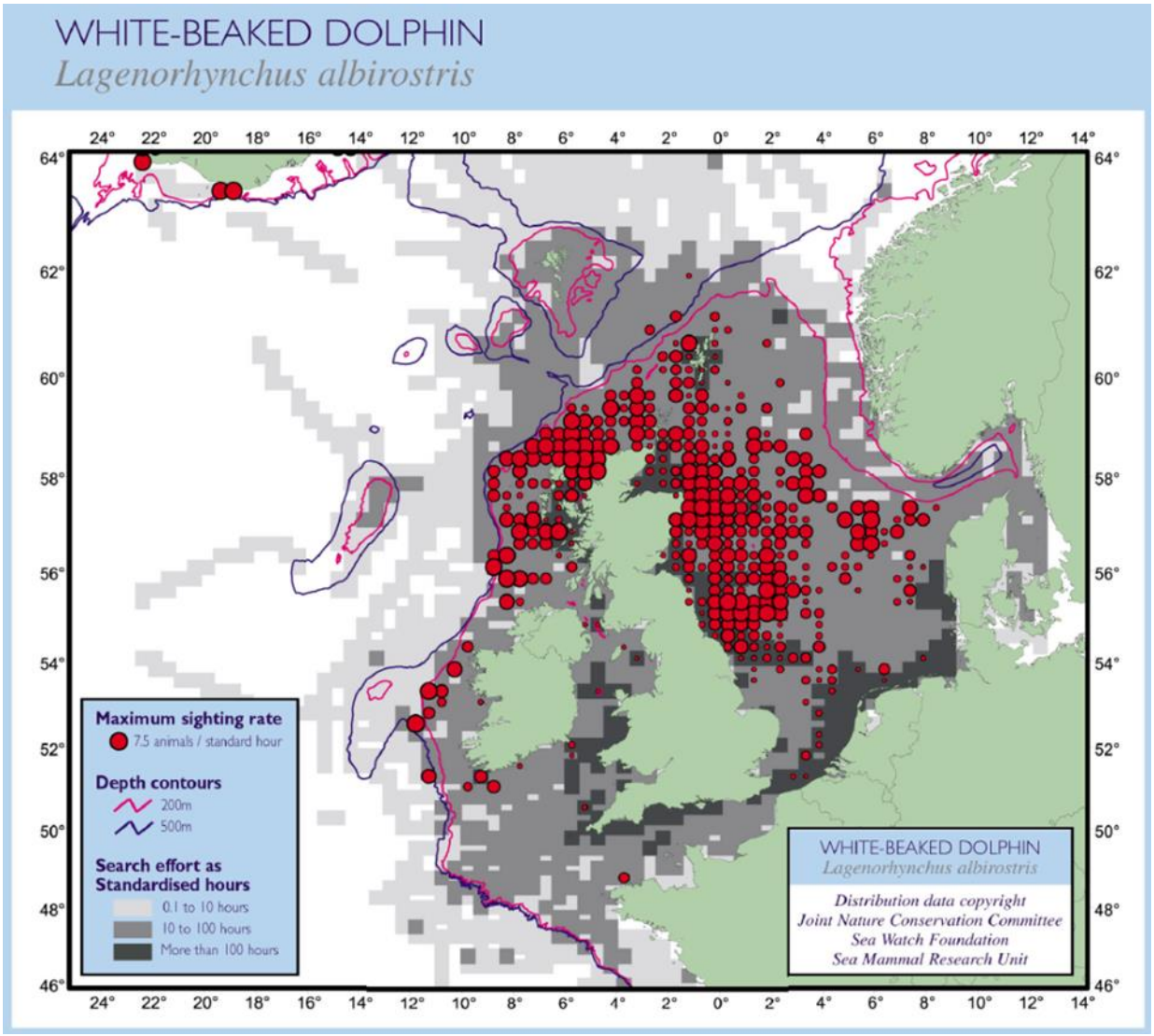

Figure 5.1.8: White-beaked dolphin´s distribution in UK waters. Red circles indicate sighting rates (maximum 7.5 animals/hour). Grey squares represent survey effort [26]

Atlantic White-sided Dolphin (*Lagenorhynchus acutus*)

Distribution

This species is widespread in the North Atlantic region, although it is more limited on the east coast of the UK. They rarely enter the Baltic Sea and/or the southern North Sea off Brittany (France), however sightings have been confirmed as far south as the Strait of Gibraltar [20]; [22].

Population Estimate

The global population exceeds 100,000 individuals. In 2004, 21,371 individuals were estimated off the west coast of Scotland (Figure 5.1.9) [20]; [17].

IUCN Status

Assessed as Least Concern in 2008 [20].

Biology

The white-sided dolphin is commonly a pelagic and deep ocean species. In the North Sea, white-sided dolphin mainly feed on oceanic cephalopods and seasonal variation fish species, which has suggested inshore-offshore migration following their preferred prey [17]. White-sided dolphins give birth in summer (May-August) [26].

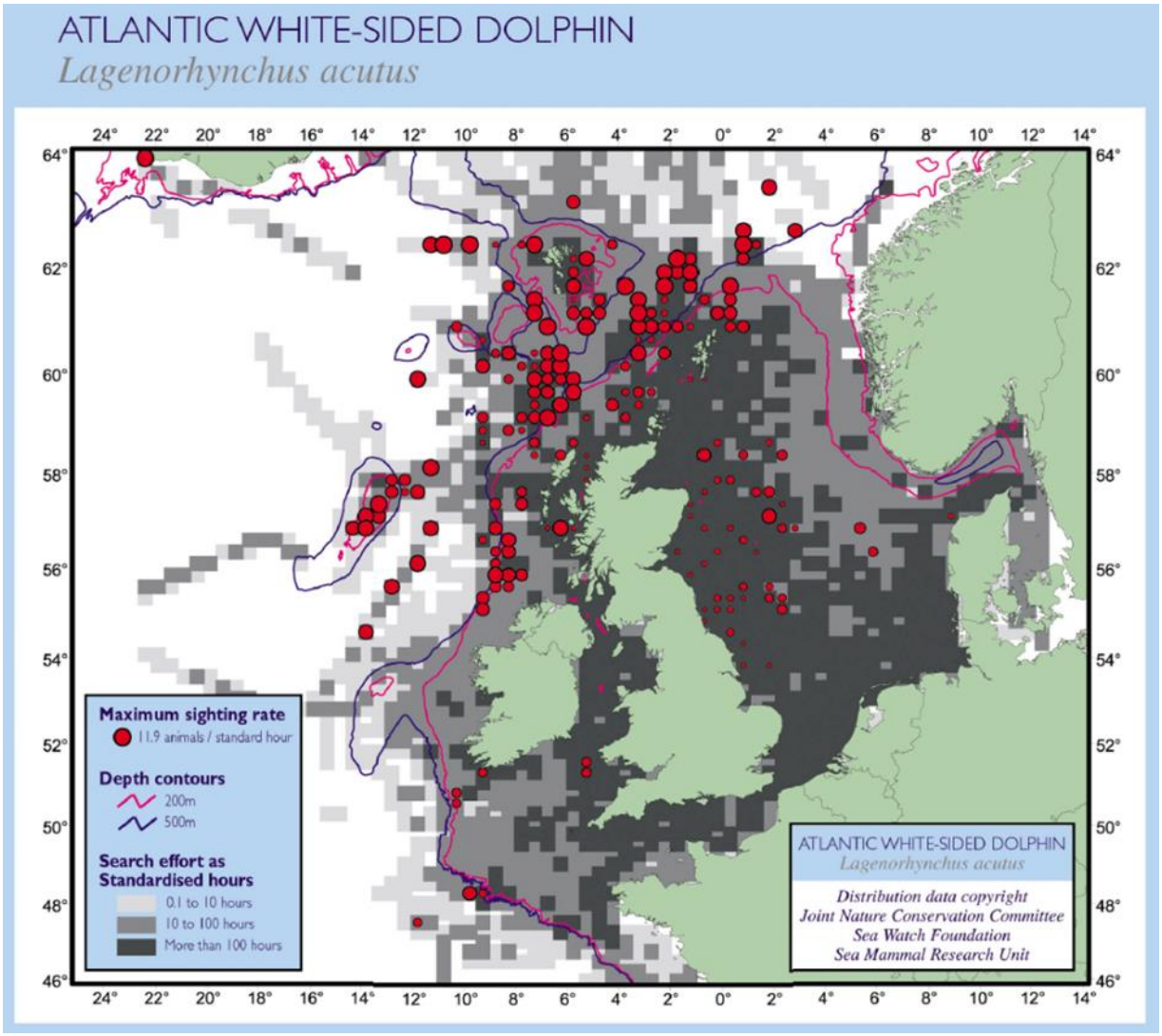

Figure 5.1.9 Atlantic White-sided dolphin´s distribution in UK waters. Red circles indicate sighting rates (maximum 11.9 animals/hour). Grey squares represent survey effort [26].

Risso's Dolphin (*Grampus griseus*)

Distribution

Risso's dolphin is globally distributed, from tropic to temperate waters (surface water temperature above 10° C) in both hemispheres. In the North Atlantic region, the distribution is mainly around the continental slope and deeper waters (generally 400-1000 meters) [20] and predominantly around the north west coast of the UK (see Figure 5.1.10).

Population Estimate

There are no estimates of the global population size. The Risso's dolphin population size in the North Atlantic was estimated to be 20,500 individuals in 2004 [17].

IUCN Listing

The population is assessed as Least Concern in 2012 [20].

Biology

The habitat of the Risso's dolphins is primarily at the continental slope, where they feed on cephalopods [20];[17]. The species does not participate in large migrations. Some inshore-offshore migration is observed and may be linked to water temperature [17].

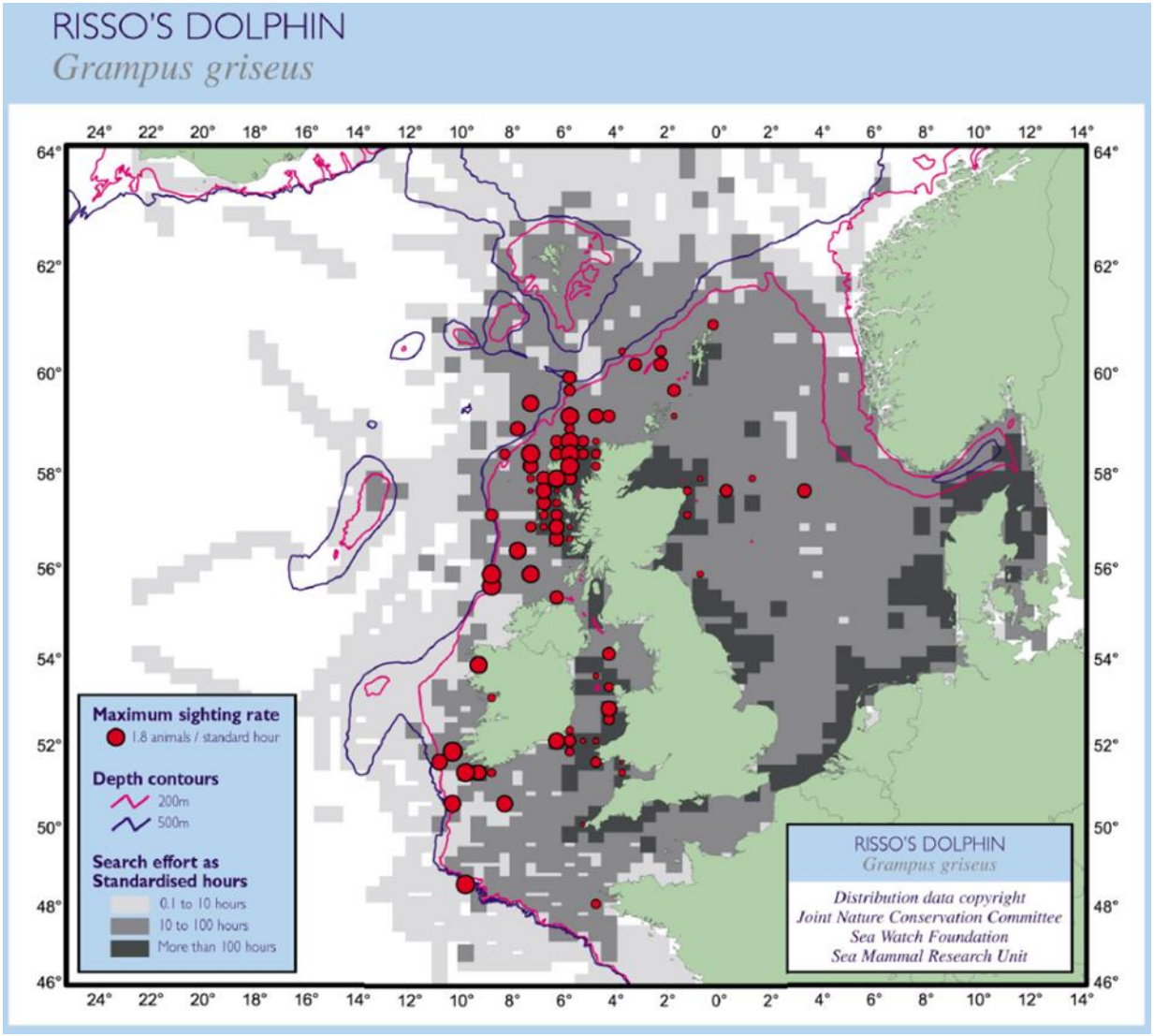

Figure 5.1.10: Risso´s dolphin´s distribution in UK waters. Red circles indicate sighting rates, maximum 1.8 animal/hour. Grey squares represent survey effort [26].

Killer Whale (*Orcinus orca*)

Distribution

Killer whales have a global distribution. Most observations in UK waters are of singles or family pods with an average of eight individuals [26].

Population Estimate

Estimates suggest that there is a minimum of 50,000 individuals on a global scale. The largest abundance is found around the Arctic and Antarctic or in areas with high productivity (e.g. off Argentina). Older sightings suggest a population between 3,500 and 12,500 individuals off the coast of Iceland and the Faroe Islands. Sightings in UK waters are mostly along the northern and west coast of Scotland [26] (see Figure 5.1.11).

IUCN Status

Despite being well studied, their large range and long lifespan gives an uncertainty in numbers. Therefore they were assessed as Data Deficient (D.D.) in 2013 [20].

Biology

Killer whales are divided into three groups; Residents, Offshores and Transients, referring to their preferred prey species, habitats and social structures [20]; [17].

Killer whales in general have a slow reproduction rate because only high ranking females give birth, with an average of one calf every 5th year [20] .

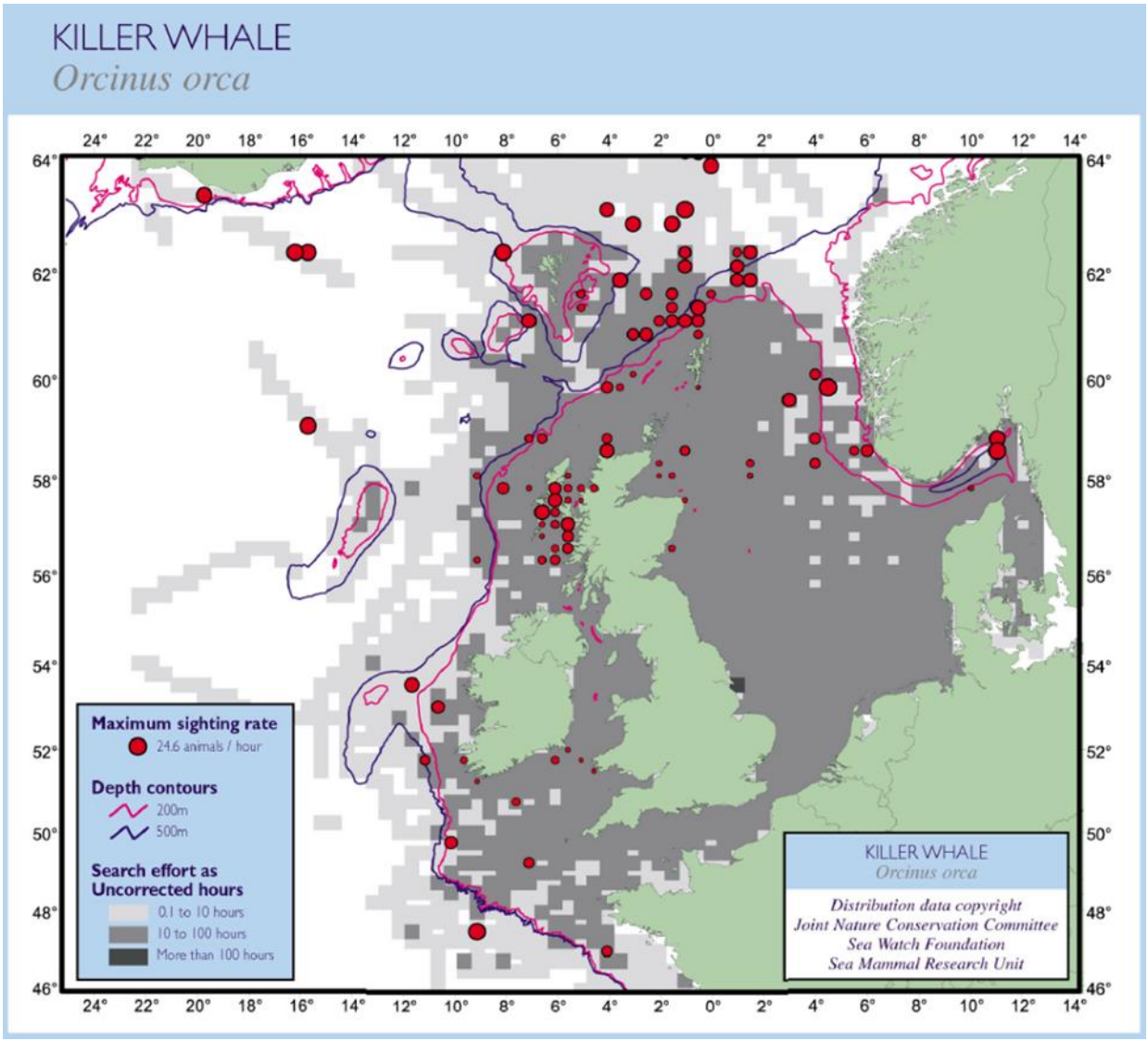

Figure 5.1.11: Killer whales distribution in UK waters. Red circles indicate sighting rates, maximum 24.6 animal/hour. Grey squares represent survey effort [26].

Long-finned Pilot Whale (*Globicephala melas*)

Distribution

Long-finned pilot whales are found all over the North Atlantic. Their main habitat includes the continental slope and deeper waters (300-1,000 meters depth). In the Northeast Atlantic, distribution is mainly around the coastal and shelf waters. They tend to follow their prey (cephalopods and mackerel) into shallow waters in summer and autumn and out to deeper waters in winter and spring [20].

Population Estimate

Global population size is unknown. Sightings from 1987-1989 suggest a population on 750,000 individuals in central and N.E. North Atlantic. In UK waters, their abundance reflects their preferred habitat along the continental slope (off the north and west coast of Scotland – see Figure 5.1.12) [26].

IUCN Status

The species is assessed as Least Concern in 2008 (IUCN, 2016).

Biology

Pod size can range from 100-1,000 individuals [17] . The long finned pilot whale feed mainly at night, performing deep dives for oceanic cephalopods and varying fish species. In the day time, especially around sun rise, they rest floating or logging at the surface. Some inshore-offshore and seasonal migration along the continental shelf has been correlated to the abundance of squid [17]

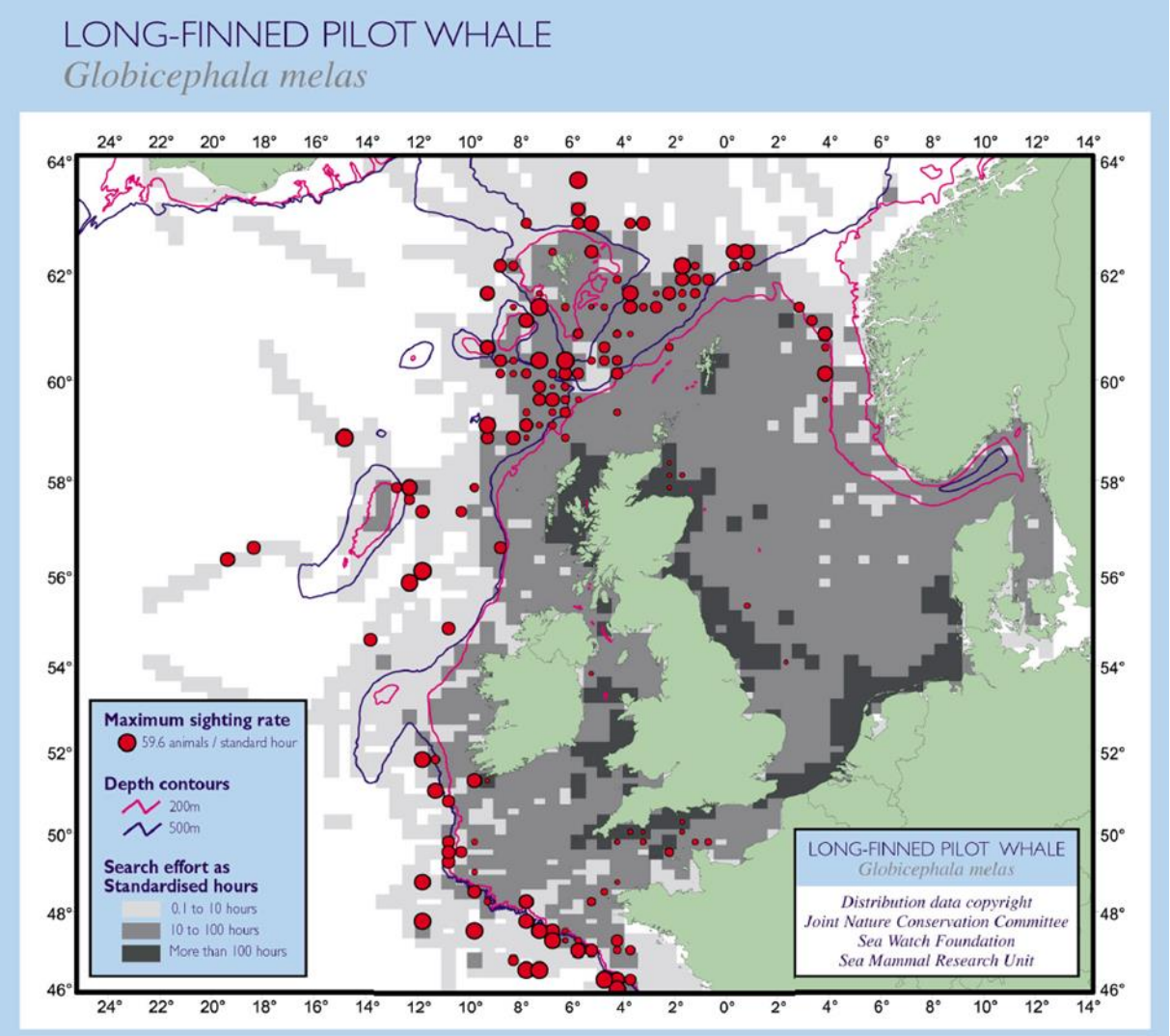

Figure 5.1.12: Long-finned pilot whales distribution in UK waters. Red circles indicate sighting rates, maximum 59.6 animal/hour. Grey squares represent survey effort [26].

Noise Modelling Results

Modelling of underwater noise has been undertaken using the dBsea model.

Jet Cutting

Southall et al. [1] recommend calculating SEL over a period of 24 hours. However, for continuous underwater noise of longer duration (e.g. jet cutting), it is likely that the animal will move away from the sound source. For that reason, jet cutting has been modelled for two scenarios: 24 hour cumulative, where a static animal remains in position for the duration of the sound source, and two hour cumulative, where an animal displays response behaviour and moves away from the sound source.

The calculated distances using threshold values (presented earlier in this section) are presented in Table TA 5.1.10.

Table TA 5.1.10: Distance to thresholds for PTS, TTS and behavioural response during jet cutting at Brae Alpha and Brae Bravo.

Distance (m) to jet cutting threshold (2 h)

Functional hearing group	PTS		TTS		Behavioural response	
	SPL	SEL	SPL	SEL	SPL	SEL
Pinnipeds in water	0 m	100 m	0 m	2,500 m	0 m	n/a
High frequency cetaceans	0 m	0 m	0 m	0 m	0 m	n/a
Mid-frequency cetaceans	0 m	0 m	0 m	0 m	0 m	n/a
Low-frequency cetaceans	0 m	0 m	0 m	400 m	0 m	n/a

Distance (m) to jet cutting threshold (24 h)

Functional hearing group	PTS		TTS		Behavioural response	
	SPL	SEL	SPL	SEL	SPL	SEL
Pinnipeds in water	0 m	500 m	0 m	12,000 m	0 m	n/a
High frequency cetaceans	0 m	0 m	0 m	100 m	0 m	n/a
Mid-frequency cetaceans	0 m	0 m	0 m	200 m	0 m	n/a
Low-frequency cetaceans	0 m	0 m	0 m	2,000 m	0 m	n/a

Proposed Mitigation

There are four main methods for mitigating the impacts from underwater noise:

- Spatio-temporal considerations;
- Reduce generated underwater noise;
- Reduce propagation of underwater noise, and
- Reduce exposure to underwater noise.

Jet Cutting

Jet cutting is assessed to have a minor effect on the marine mammals in the area, and no additional mitigation measures are required. However, additional reductions in the impact can be achieved by reducing exposure to underwater noise.

Potential impacts of jet cutting are minor. However, impacts could be further reduced through the use of acoustic deterrents. Evidence relating to the efficiency of acoustic deterrents such as “scrammers” or “pingers” is currently limited, though there is good evidence that pingers are very efficient in keeping harbour porpoise several hundred meters away, thus away from the zone of PTS [30].

As part of the consultation process, JNCC has highlighted that the JNCC guidelines for minimising the risk of injury to marine mammals from piling noise would be the most appropriate for the cutting work [31]. It is noted that jet cutting has a different potential impact to marine mammals than pile driving.

Technical Appendix 5.2: Seabed Disturbance Effects

Introduction

This technical appendix provides further detail to support the assessment presented in the Environmental Statement: Main Report, ES Chapter 5: Summary of Environmental Effects.

Physical Characteristics

Seabed sediments were analysed from a total of 18 sampling stations around the Brae Alpha platform during the March 2015 pre-decommissioning environmental survey. Sample locations ranged from 250 m to 5,000m from the platform centre. In addition, 16 locations were sampled within 100 m of the platform centre to characterise the drill cuttings pile sediments.

Seabed sediments were analysed from a total of 14 sampling stations around the Brae Bravo platform during the September 2013 environmental monitoring survey. Sample locations ranged from 500 m to 5,000 m from the platform centre. Fifteen additional samples were taken from within 170 m of the Brae Bravo Platform to characterise the cutting pile sediments.

Sediment sampling was undertaken at 12 locations for the West Brae subsea manifold area in March 2015. The sample locations ranged from 250 m to 2,000 m from the manifold. No drill cuttings pile is present at West Brae.

Sampling was also undertaken at 15 locations for the Central Brae subsea manifold. The 15 sample locations ranged from 250 m to 5,000 m from the manifold. There is no drill cuttings pile at Central Brae.

Six sampling stations were located in the wider area' (i.e. the samples taken 5 km to 20 km from platforms or manifolds) as part of the 2013 monitoring programme for Brae Bravo (locations up to 17 km away from Brae Bravo).

A summary of physical sediment characteristics is presented in Table TA 5.2.1.

Table TA 5.2.1: Mean characteristics of seabed sediment by location

Structure	Brae Alpha	Brae Alpha cuttings pile	Brea Bravo	Brae Bravo cuttings pile	West Brae	Central Brae	Wider Area
Mean diameter (µm)	122 (SD=22)	162 (SD=94)	193 (SD=31.9)	140 (SD=67)	145 (SD=27)	168 (SD=19)	102 (SD=41.7)
Silt/clay content (%)	16.0 (SD=4.6)	28.3 (SD=14.9)	8.1 (SD=1.3)	25.6 (SD=12.2)	9.9 (SD=2.9)	9.5 (SD=1.3)	22.8 (SD=12.5)
Wentworth scale	Very fine sand to fine sand	Coarse silt to medium sand	Fine sand to medium sand	Very fine sand to medium sand	Very fine sand to fine sand	Fine sand	Very coarse silt to fine sand
Carbonate %	5.8 (SD=1.7)	No data	3.0 (SD=1.5)	11.1 (SD=6.5)	3.19 (SD=0.7)	3.63 (SD=1.1)	5.9 (SD=3.2)
Organic %	1.46 (SD=0.5)	No data	1.0 (SD=0.2)	3.8 (SD=1.8)	2.03 (SD=0.5)	1.72 (SD=0.5)	1.75 (SD=0.7)
TOC%	0.35 (SD<0.1)	1.51 (SD+0.95)	<0.4 (SD=0.6)	1.0 (SD=0.4)	0.28 (SD<0.1)	0.25 (SD<0.1)	0.55 (SD<0.1)

SD = Standard deviation between the sample means

* SD within the sample measurements (single sample)

Sediment Chemistry

Summaries of the pre–decommissioning surveys carried out at Brae Alpha and Brae Bravo during 2015 are set out within Chapter 3 of the ES.

A summary of sediment chemistry results including the screening criteria used is presented in Tables TA 5.2.2, TA 5.2.3 and TA 5.2.4.

Core samples from Brae Alpha drill cuttings pile exceeded ERLs in a majority of samples for PAHs, nonylphenol, TBT, arsenic, barium, copper and zinc (Table TA 5.2.3). Cadmium exceeded the ERL in a minority of samples (<20%) and chromium exceeded only at depth. This indicates that the sediments are likely to cause rare adverse effects to benthic organisms (i.e. have been shown to cause adverse effects in approximately 10% of studies (dependant on the specific contaminant)). There were no exceedances beyond 250 m of the platform except mercury, which exceeded in all samples. Mercury, nickel and zinc also exceeded ERMs within core samples, indicating that they are likely to cause occasional adverse effects to organisms if ingested (i.e. approximately 50% of available Brae Area specific studies show adverse effects at the ERM concentrations exceeded).

Surveys of the Brae Alpha drill cuttings pile and surrounding area in 2013 and 2015 concluded that THC levels were significantly lower than previously recorded in 1983, 1985 and 1989. Also metal concentrations were evenly spread throughout the survey area, but particularly elevated concentrations were located at two station (BA01 and BA07) both located 250 m from the platform centre, although on opposite sides of the platform.

Core samples from Brae Bravo exceeded ERLs in a majority of samples for PAHs, nonylphenol, arsenic, barium, copper, mercury, nickel and zinc (Table TA 5.2.4). A minority of samples in both the shallow and deep cores also exceeded screening criteria for octylphenol and TBT. The same contaminants also exceeded ERLs in grab samples surrounding the drill cutting pile. There were no exceedances beyond 250 m of the platform except for barium and mercury (although these exceeded in all samples). Mercury, nickel and zinc also exceeded the Effects Range Medians (ERMs) in some core samples from within the pile.

Surveys of the Brae Bravo drill cutting pile and surrounding area (up to 5 km distance) in 2015 and concluded that THC levels were substantially elevated in comparison to historical survey data and background data for the North Sea (UKOOA, 2001), but were comparable to other drill cuttings piles in the North Sea.

Contaminant analysis of sediments at West Brae indicates that THCs were mostly below 25 µg/g, apart from a single sample which had a substantially higher THC of 201 µg/g – this station was 250 south of West Brae. The THCs at Central Brae were assessed to be lower, ranging from 2.8 µg/g to 41.3 µg/g. The concentrations at West Brae and Central Brae were generally comparable to those observed at Brae Alpha (greater than those observed at Brae Bravo). At West Brae metal concentrations exceeded ERLs for arsenic, copper and nickel. The concentrations of copper also exceeded ERMs. At Central Brae, there were exceedances of ERLs for nickel, copper and barium. This indicates that adverse effects to organisms may frequently occur when exposed to these sediments.

Table TA 5.2.2: Criteria used in the screening analysis

Contaminant of Concern	Screening Criteria
Hydrocarbons	Total hydrocarbon concentration (THC): No criteria for THC have been set through the OSPAR Coordinated Environmental Monitoring Programme (CEMP) and no other screening criteria exist for "total" concentrations. For the purposes of this assessment, concentrations have been compared against the regional background THC concentration reported in the North Sea Quality Status Report (NSTF, 1993) of 5,000 µg g^{1}. Polycyclic aromatic hydrocarbons (PAHs): BCs, BACs and EACs have been defined for specific PAH compounds through the CEMP; however as the EACs are in some cases lower than the BACs, the ERL for Total PAHs of 3.34 µg g^{-1} has been adopted for the purposes of this assessment.
Polychlorinated Biphenyls (PCBs)	The OSPAR BAC value for PCBs is 0.35 ng g^{-1}. The ICES7 PCB ERL of 11.5 ng g^{-1} has been adopted in this assessment.
Alkylphenols and Alkylphenol Ethoxylates (APEs)	No criteria for APEs have been set through the CEMP and no other screening criteria exist; however various studies have been conducted investigating the sources and fate of APEs in the North Sea. For the purposes of this assessment, APE concentrations have been compared to background concentrations recorded in the Dutch North Sea by Jonkers et al (2005) and OSPAR (various).
Tributyl Tin (TBT)	No formal BAC or EAC for TBT have been set through CEMP, although limits have been proposed via various OSPAR programmes and meetings. In 2009, OSPAR reported a provisional EAC for TBT as 0.01 ng g^{-1}. This value has been adopted in this assessment.
Metals	ERLs have been set through the CEMP for arsenic (8.2 µg g^{-1}), cadmium (1.2 µg g^{-1}), chromium (81 µg g^{-1}), copper (34 µg g^{-1}), lead (47 µg g^{-1}), mercury (0.15 µg g^{-1}), nickel (20.9 µg g^{-1}) and zinc (150 µg g^{-1}) have been set through the CEMP. The TEL for barium (130 µg g^{-1}) has also been adopted in this assessment.

NOTES:

Abbreviations: background concentrations (BC), background assessment criteria (BAC), environmental assessment criteria (EAC), effects range (ER), Effects Range Low (ERL), Effects Range Median (ERMs), Tolerable Effects Level (TEL) and Probable Effects Level (PEL).

According to OSPAR (2010), EAC represent the contaminant concentrations in the environment below which no chronic effects are expected to occur in marine sediment species. Some EACs are not used in OSPAR assessments because they are less than the BACs (i.e. adverse effects could be observed even at background concentrations). OSPAR (2010) recommends the use of Effects Range Low (ERL) values in the first instance where EACs are not appropriate.

ERLs and ERMs are specific chemical concentrations that are derived from biological toxicity assays and synoptic sampling of marine sediments (approximately the 10th and 50th percentiles for observed adverse effect concentration respectively). Adverse effects in organisms are rarely observed when concentrations fall below the ERL and are occasionally observed when between ERL and ERM, and frequently observed when above the ERM. Concentrations that fall in between the ERL and ERM are indicative of a potential risk and may require further assessment. One of the limitations of ERLs is that they take no account of grain size.

TELs and PELs are similar to ERLs/ERMs in their derivation; however ERL/ERM calculations are based only on samples categorised as toxic, while TELs and PELs also include non-toxic samples. Caution should be applied as these values are representative of pristine environments.

Table TA 5.2.3: Brae Alpha – Summary of Screening Comparison

	Surrounds and cutting pile grabs		Shallow Cores		Deep Cores	
µg/g (dry weight)	Range	Total Exceedances (of 30)	Range	Total Exceedances (of 6)	Range	Total Exceedances (of 29)
THC	5-80,900	2	3990-53,700	4	31-113,000	29
PAHs	0.08-194	9	14.4-507	6	0.3-618	29
PCBs	0.54-1.98	0	1.0-3.6	0	0.56-1.98	0
Octylphenol	1-46.7	0	6.3-28.7	0	1.3-20	0
Nonylphenol	21-1,480	6	250-1,810	6	29-23,700	27
TBT	<LOD-4.09	10	0.82-10.75	6	<LOD-1.54	7
Arsenic	2-22	10	8.64-27.3	6	2-37	24
Barium	121-4976	27	1,020-2,921	6	139-5,616	29
Cadmium	0.02-3.43	3	0.35-3.37	1	0.02-8.36	4
Chromium	9-94	5	28.9-57.8	0	3-115	7
Copper	2-259	13	23.8-112	5	2-94	22
Lead	0.005-1.39	0	0.127-1.192	0	0.007-3.677	0
Mercury	3-45	30	11-21.2	6	2-124	29
Nickel	5-425	11	139-467	6	6-401	25
Zinc	9-5,180	12	150-2,110	6	11-3,610	25

Concentrations expressed as ugg-1 except PCBs, octylphenol, nonylphenol and TBT (ngg-1), LOD – Limit of Detection

Table TA 5.2.4: Brae Bravo – Summary of Screening Comparison

	Vibrocores		Surrounds and cuttings pile grabs	
µg/g (dry weight)	**Range**	**Total Exceedances (of 18)**	**Range**	**Total Exceedances**
THC	3-76,600	14	2-47,000	12
PAHs	0.01-243	8	0.02-132	15
PCBs	0.03-0.79	0	0.12-1.0	0
Octylphenol	0.1-156	1	0.4-23	0
Nonylphenol	5-33,700	5	24-6,010	11
TBT	<LOD-1.56	3	<LOD-59	13
Arsenic	1-35	6	1.6-23	11
Barium	11-4,810	9	36-3,110	20
Cadmium	0.01-1.0	0	0.01-3.21	9
Chromium	2-84	1	6-71	0
Copper	1.0-126	5	1.0-367	11
Lead	1.0-324	5	4-570	11
Mercury	0.03-1.0	6	0.03-3.21	11
Nickel	0.93-104	6	2-57	7
Zinc	3-723	5	7-2,350	12

Concentrations expressed as ugg-1 except PCBs, octylphenol, nonylphenol and TBT (ngg-1)

LOD – Limit of Detection

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9000-MIP-99-EV-RT-00001-001, I02

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