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Finding Petroleum Conference

Arctic Exploration
Does Any Of It Make Sense?

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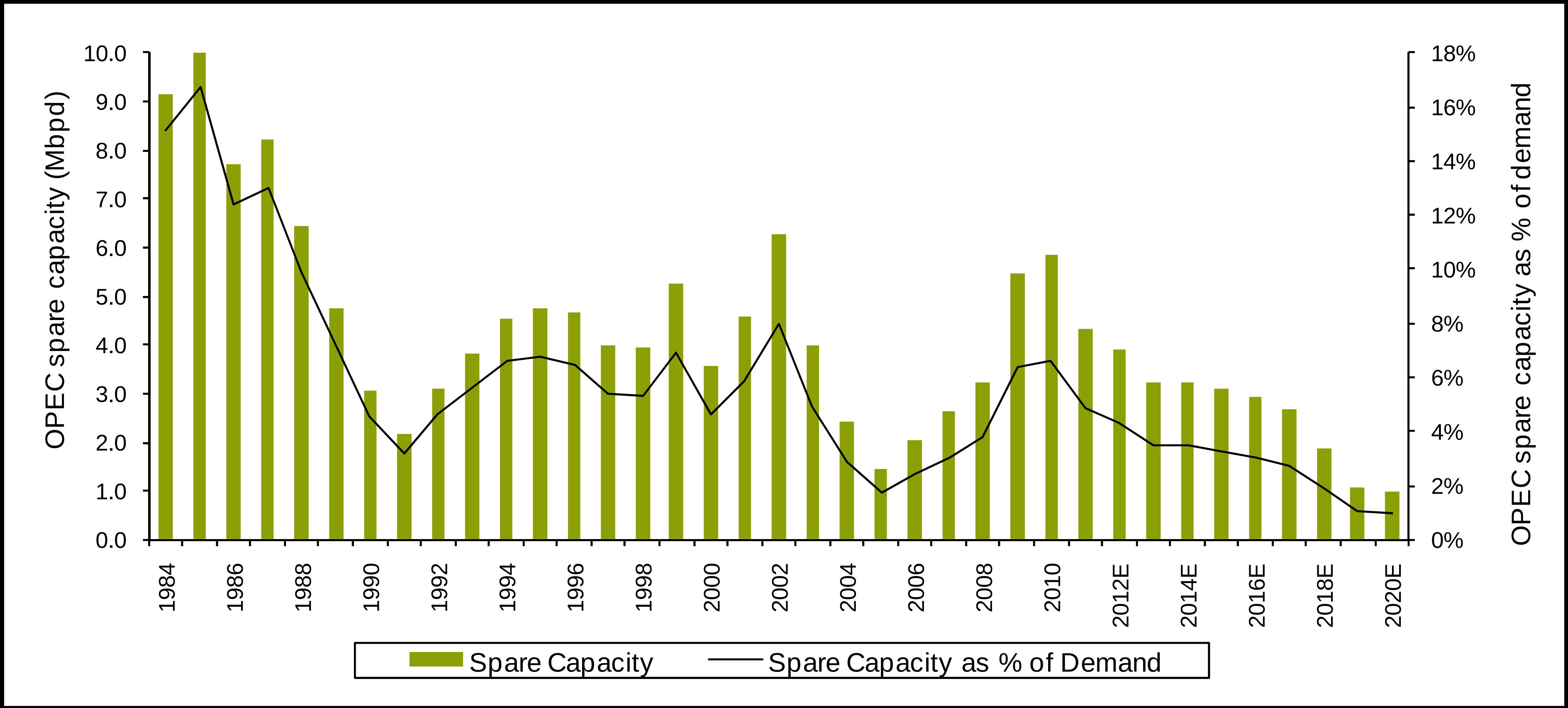
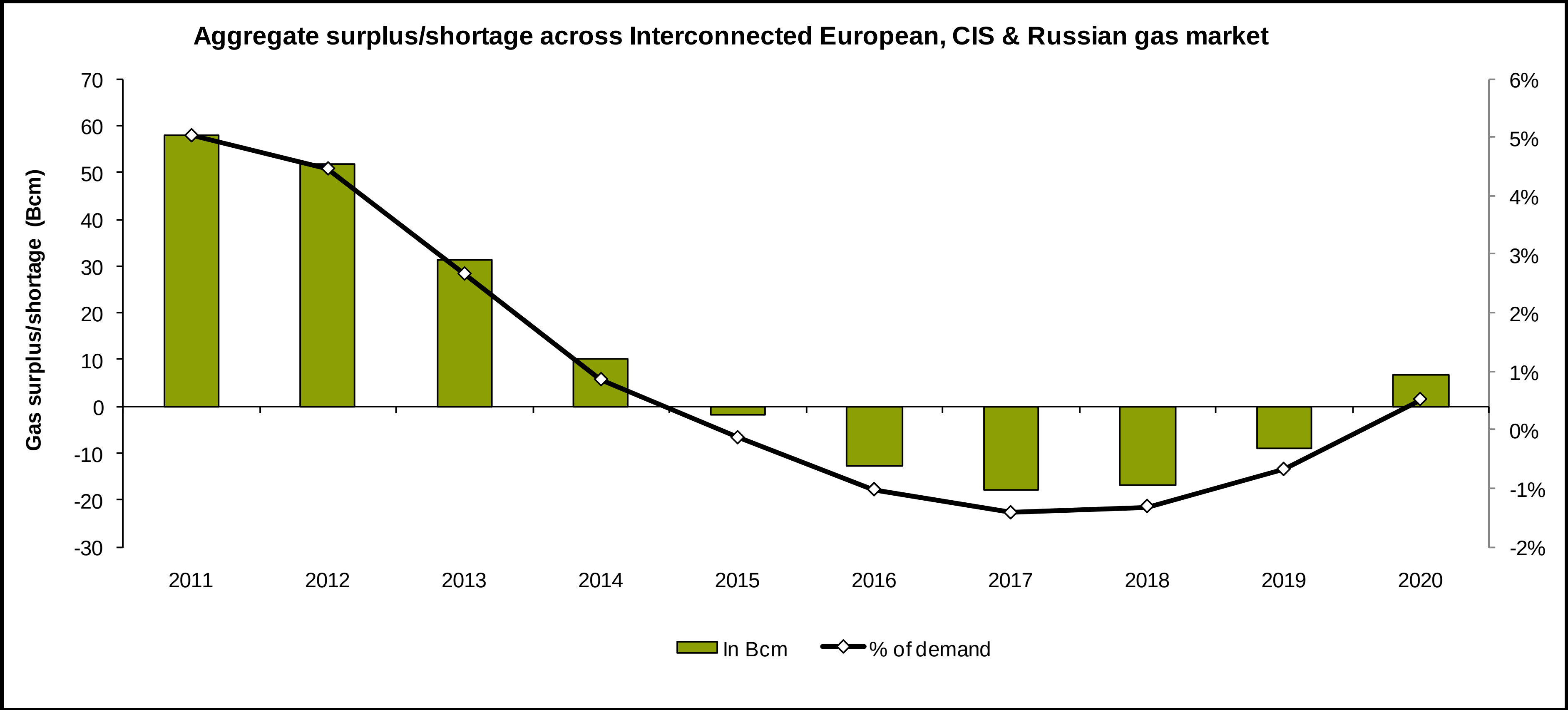
We need more oil to be discovered and developed given we expect surplus oil production capacity to fall over this decade



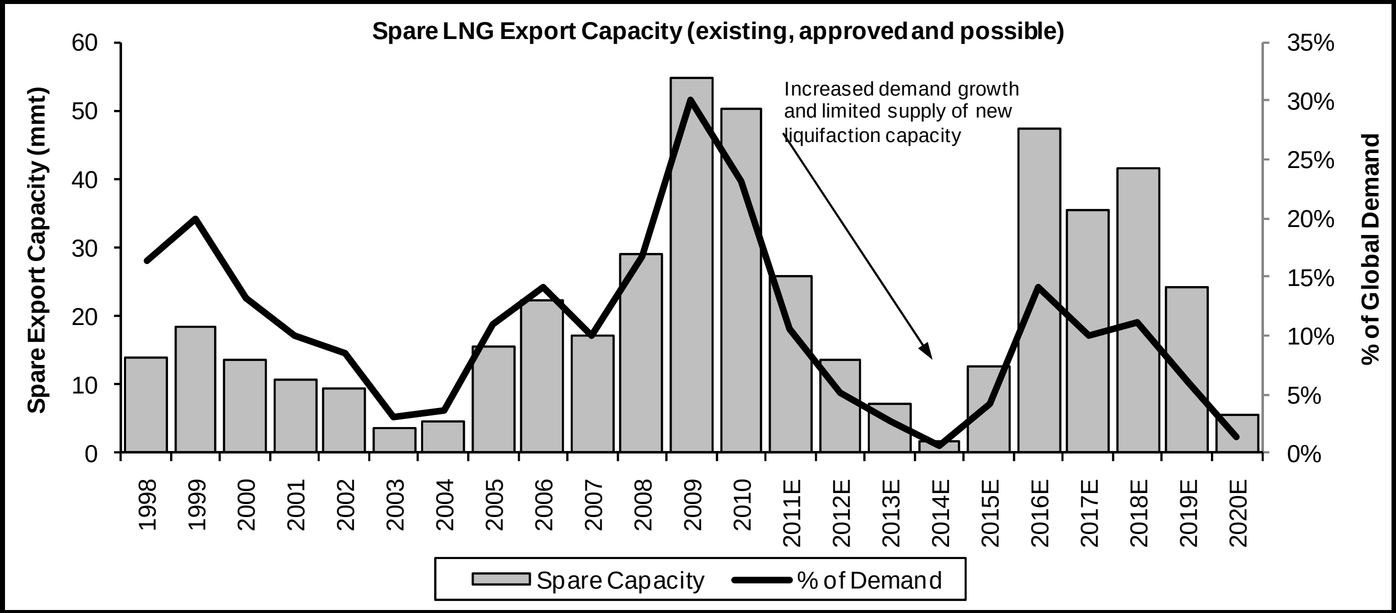
Source: Bernstein estimates

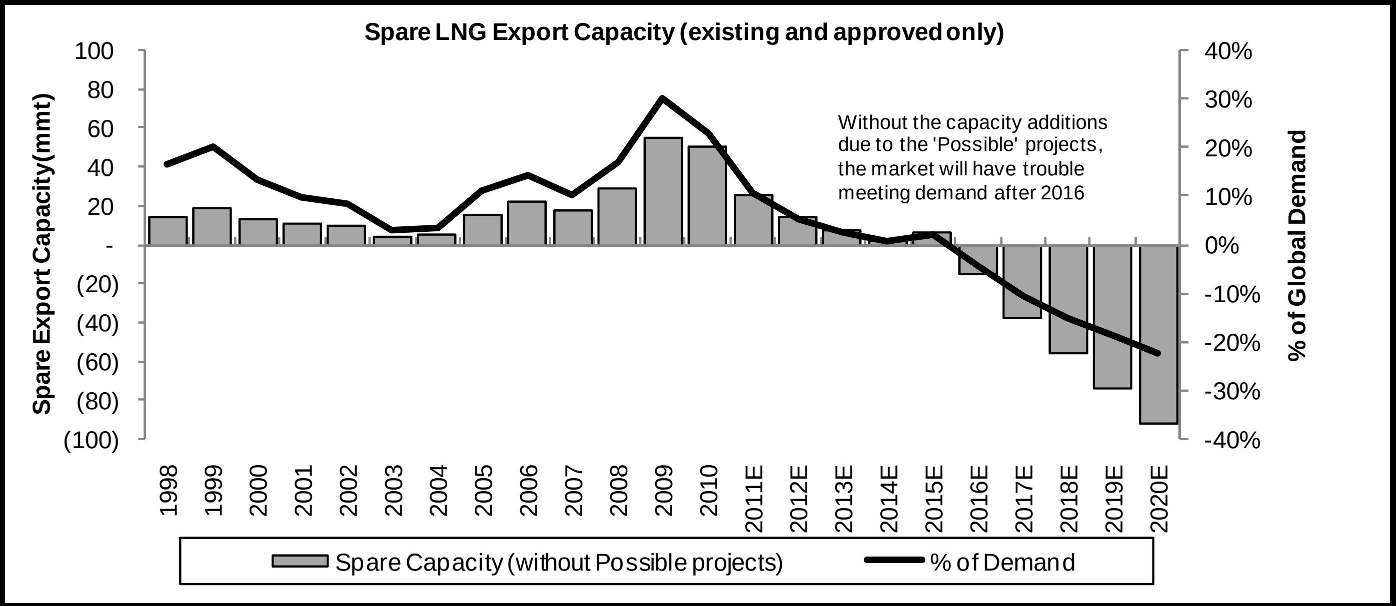
European/FSU natural gas markets also need more gas



Source: Bernstein estimates

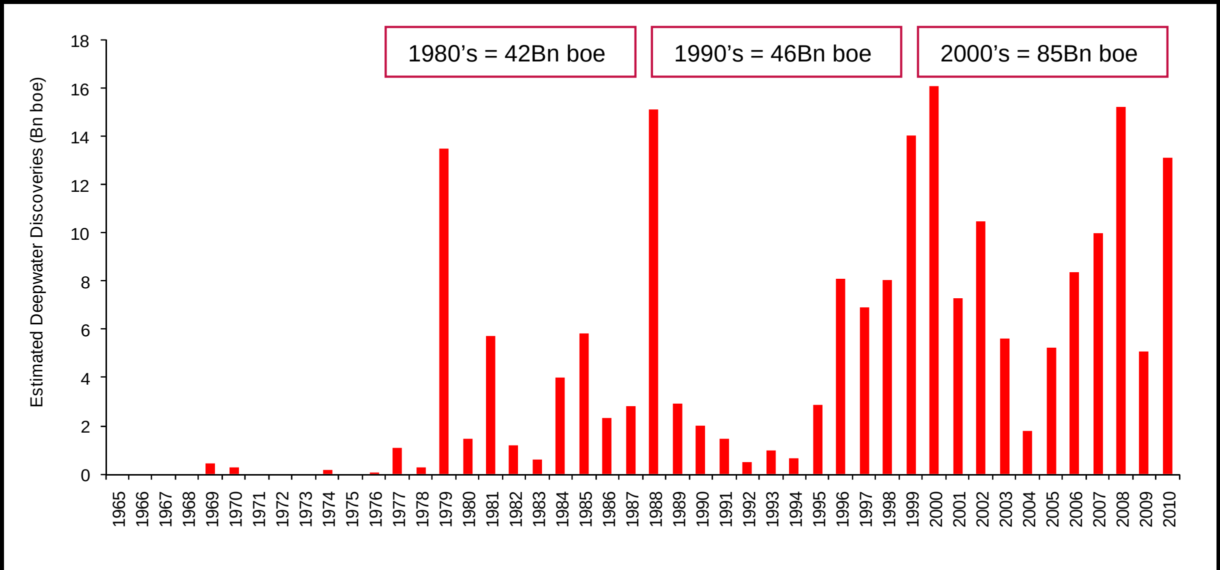
Liquefied natural gas has helped gas markets but the markets now need more

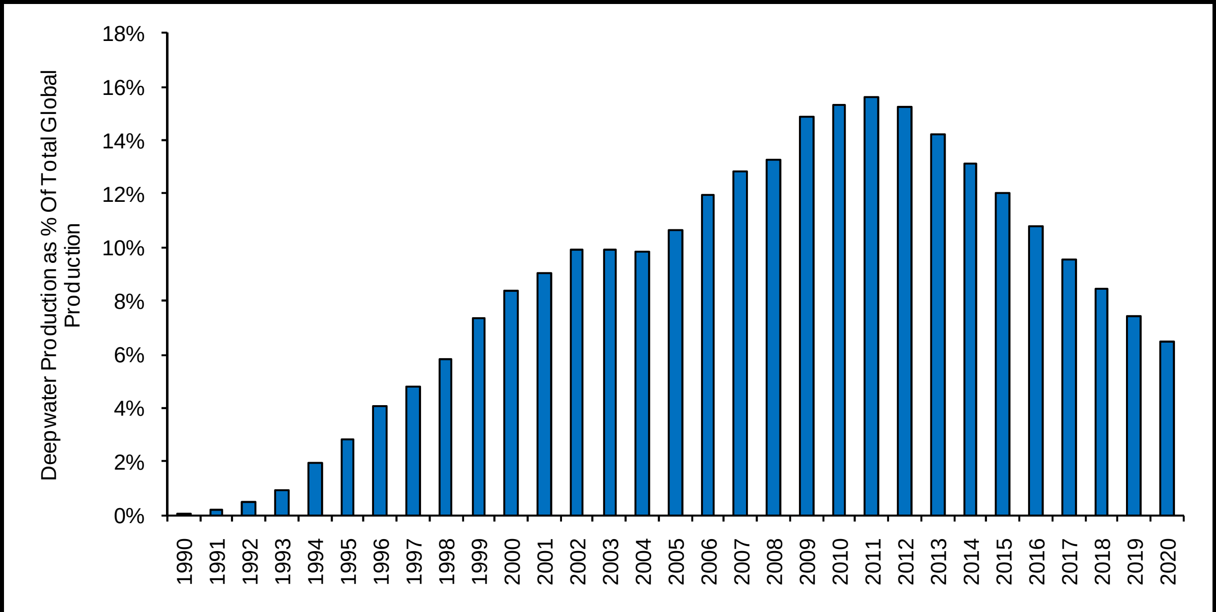




Source: Bernstein estimates

Offshore discoveries have helped but are still a small part of global supply

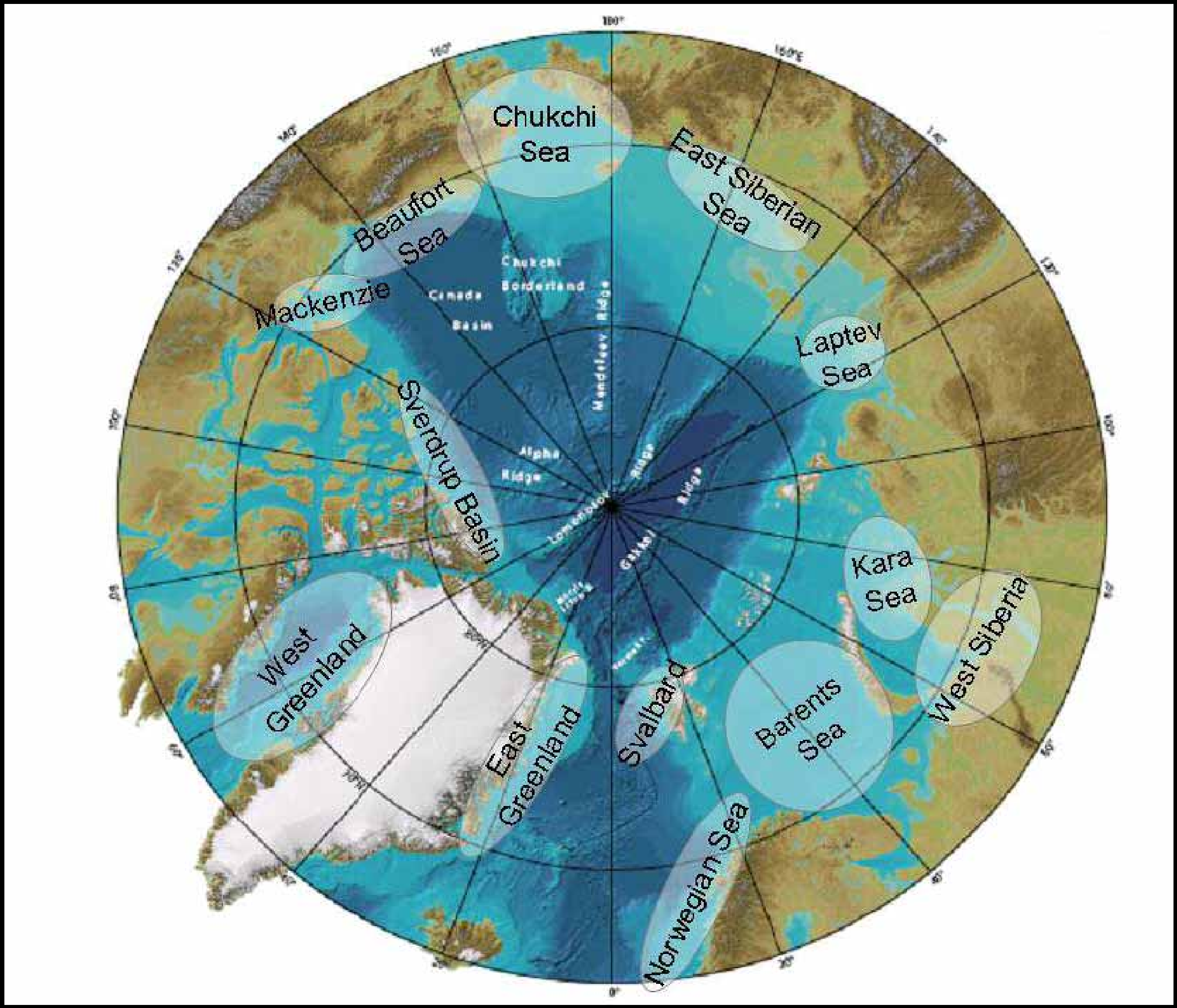




Source: World Oil, IHS and Bernstein estimates

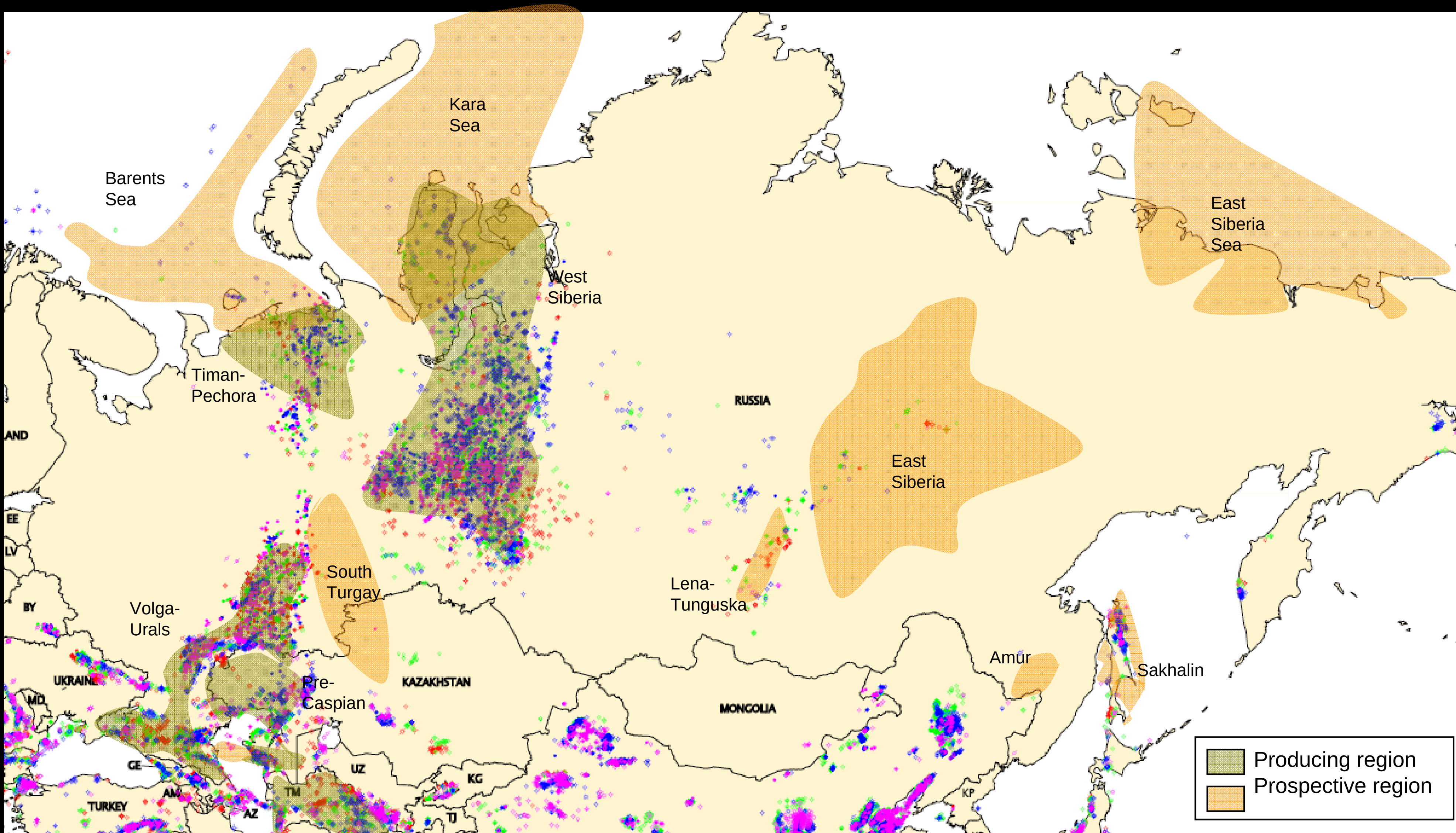
Can The Arctic Help?

Bathymetry and seismic highlights presence of Arctic basins



Source: NOAA

Extrapolating successful exploration wells offshore points to the potential upside



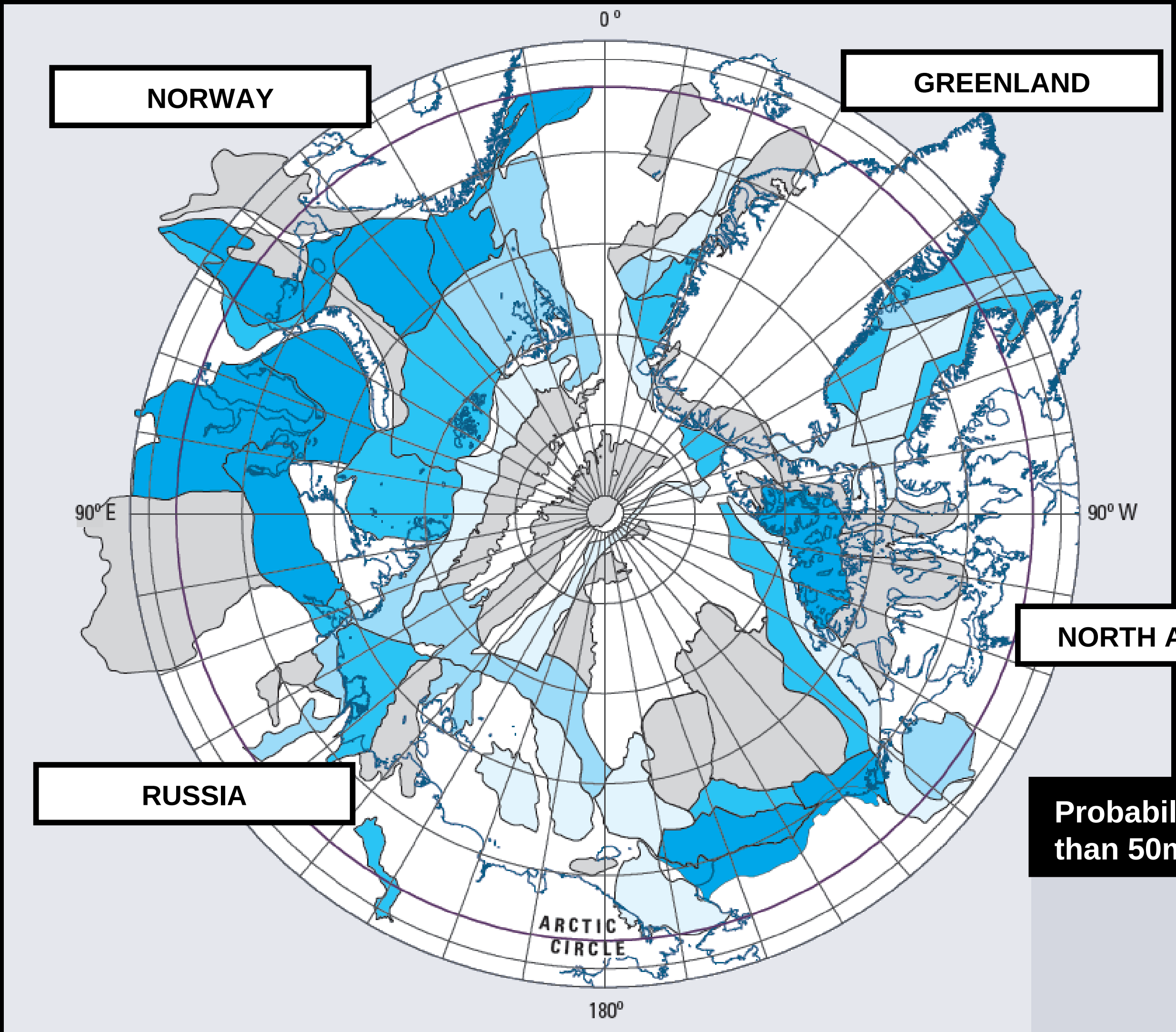
Source: IHS and Bernstein estimates

Geology of many of these offshore basins also appears favourable for hydrocarbon potential

Basin	Source	Structuration	Depositional Setting	Trap Type	Reservoir	Seal	Oil/Gas Prone	Water Depth
East Greenland	Jurassic shales, U.Carboniferous lacustrine and deep marine shales	Extensional	Shallow marine to non-marine	Structural, salt tectonism, stratigraphic traps in sub-marine fan complexes, inversion structures, fault traps	U.Jurassic shallow marine to non-marine syn-rift sandstones, Cretaceous sub-marine fans, Paleogene progrades, U.Carboniferous - L.Permian carbonates	Marine shales	Both	100-500m
Mackenzie Delta	U.Jurassic-L.Cretaceous shales, L.Cretaceous coals, U.Cretaceous formations	Rifted margin - extensional faulting with superimposed compression	Shore face, deltaic, marine shelf	Faulted complex structures, stratigraphic pinch-out of distal sandstones	Deltaic sandstones and shelfal sandstones, carbonates	Marine shales	Both	<3000m (for USGS assessment)
Chukchi	Hue-GRZ, Pebble Shale, Kingak and Shublik formations	Rifting, grabens, listric faults, trans-tensional faults, thrusts		Anticlines, fault traps, stratigraphic wedge-outs	Oligo-Pliocene and Eocene sandstones	Some terrigin ous	Both	0-3800m
Beaufort	Hue-GRZ, Pebble Shale, Kingak and Shublik formations (similar to onshore Alaska)	Rifted continental margin with folding and thrusting superimposed	Shore face, deltaic, marine shelf	Faulted complex structures, stratigraphic pinch-out of distal sandstones	Ellesmerian and Beaufortian sandstones (rift sequences, quartz rich, marine, shelf, fluvial, delta and pro-delta) and some carbonates	Marine shales	Both	<500m (for Beaufort lease sale)
Laptev	Paleogene marine oil prone and U.Jurassic mudstones and syn-rift L.Cretaceous & Paleogene coals	Compression followed by rift & sag		Extensional structures and stratigraphic traps	Synrift shelf and slope sandstones from deltas	Many possibil ities	Both	Mostly < 50m, but >1000m beyond the steep continental slope
Barents	Triassic coaly & shales	Compressional	Shallow marine	Structural, fault blocks and roll over anticlines and domes	Jurassic, Triassic and Cretaceous sandstones	Shale	Gas	~230m
Kara	Permo-Triassic & M.Jurassic terrestrial and U.Jurassic marine shales	Compressional	Non marine	Structural	Cretaceous sandstones	Marine shales	Gas	~127m (max 620m)
Yenisey-Khatanga Basin	Proterozoic & L.Paleozoic carbonates & clastics, U.Paleozoic & Mesozoic clastics			Folds and thrusts and pinch-outs				
West Greenland-East Canada	Multiple levels	Rifting, thermal subsidence, rotation and compression	Syn-rift, shore face and marine	Structural	Cretaceous-Paleocene sandstones	Shales		
Lena-Anabar Basin	Proterozoic & Cambrian, U.Paleozoic-Jurassic	Compressional structures, pinch-outs			Proterozoic & L.Paleozoic carbonate and clastics, U.Paleozic and Mesozoic clastic rocks			
Lena-Vilyui Basin	Proterozoic & Cambrian, U.Paleozoic-Jurassic	Compressional structures, pinch-outs						
Zyryanka Basin	Proterozoic & Cambrian, U.Paleozoic-Jurassic	Compressional (foreland)						

Source: USGS, BOEMRE, AAPG Memoir 86, GeoExpro

USGS studies point to high probabilities for discoveries



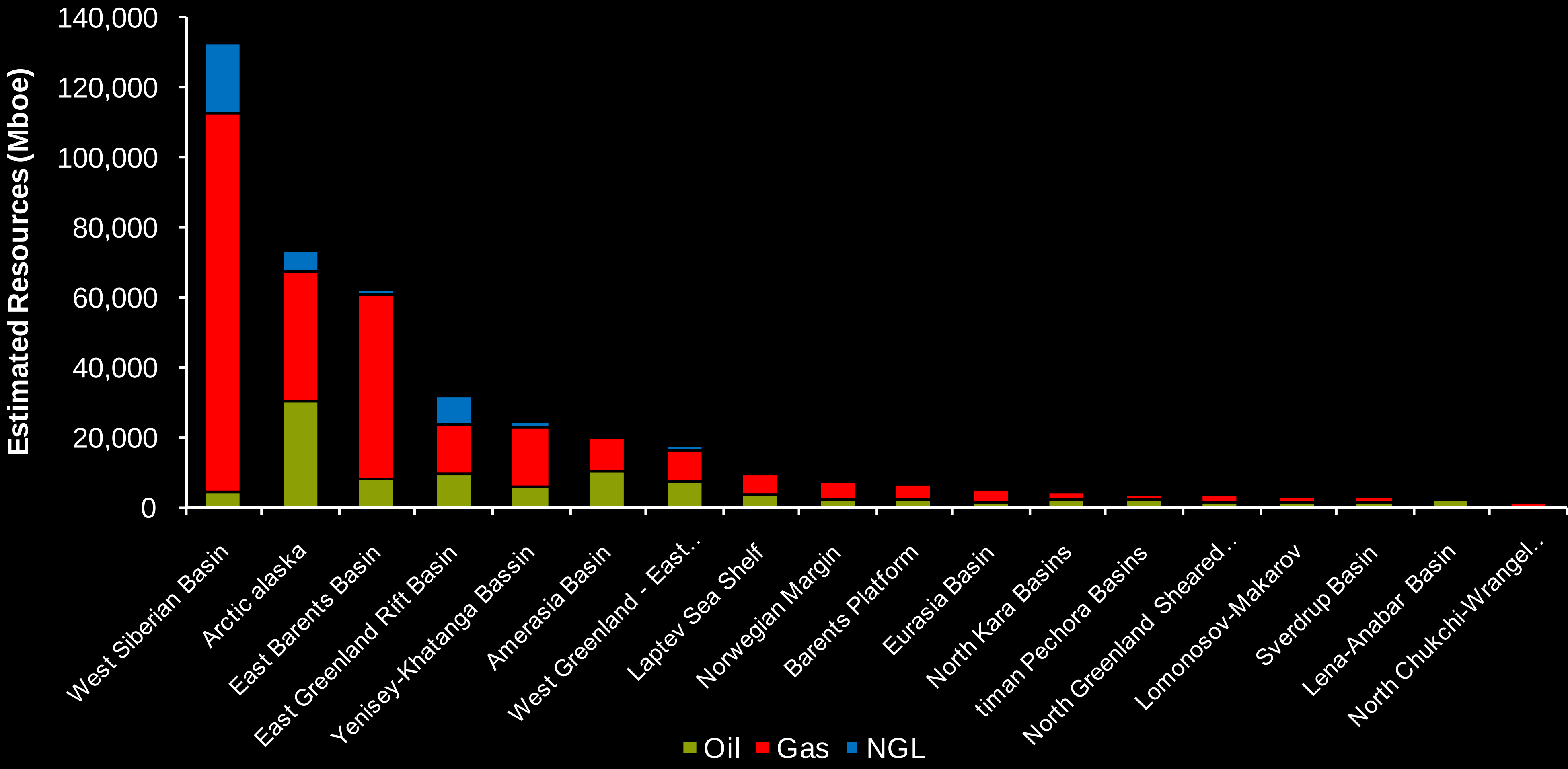
USGS sees large areas of high potential in the arctic, particularly the West Siberian basin, East Barents Basin and Arctic Alaska

Probability of finding at least one oil or gas field greater than 50mmboe (%):

- 100
- 50–100
- 30–50
- 10–30
- <10
- Area of low petroleum potential

Source: USGS

Russia and Alaska have the highest potential according to these estimates but is heavy skewed to natural gas



Source: USGS

Ultimately we don't know for sure until more wells are drilled - offshore US Arctic regions have seen little drilling activity

Alaska OCS Area	Number of Exploratory Wells	Number of Deep Stratagraphic Test Wells	Number of Development Wells	Total
Gulf of Alaska	12	1	0	
Kodiak	0	6	0	
Cook Inlet	13	1	0	
Saint George Basin	10	2	0	
North Aleutian Basin	0	1	0	
Norton Basin	6	2	0	
Navarin Basin	8	1	0	
Beaufort Sea	30	0	7	
Chukchi Sea	5	0	0	
Totals	**84**	**14**	**7**	**105**

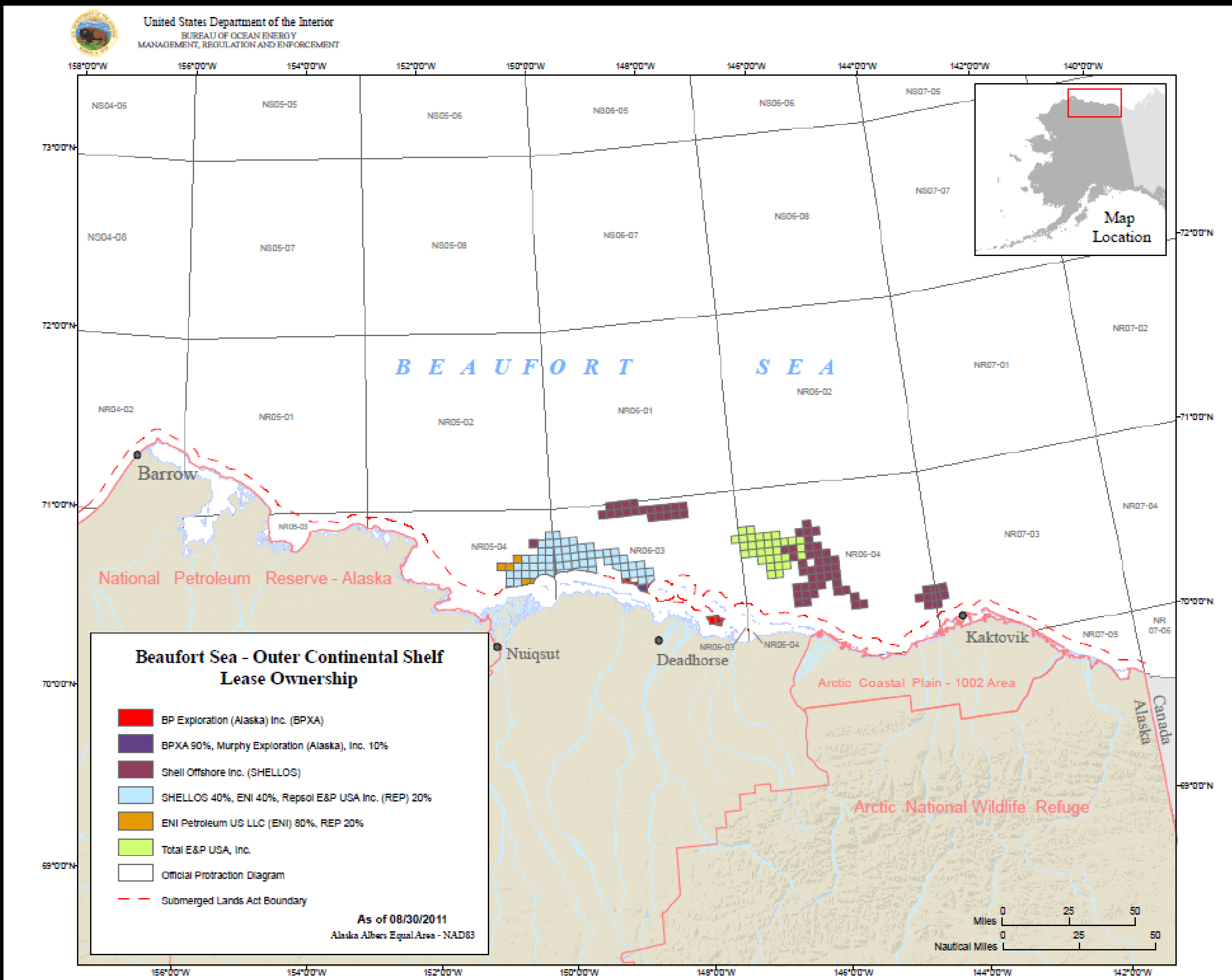
Source: BOEMRE

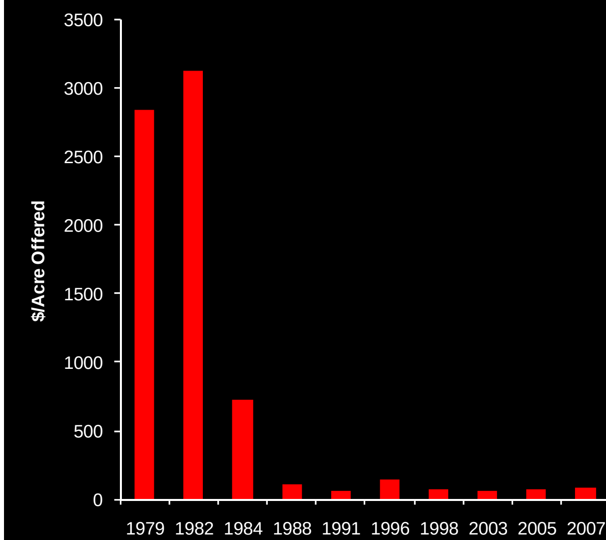
Russia has drilled some wells offshore but were predominately natural gas and condensate and none have been developed

Discovery name	Location on the Arctic	Disc. year	Wells drilled #	TD (m)	Wells tested #	TD (m)	Distance to shore (km)	Water depth	Ice-free season (mths)
Murmanskoye	Barents Sea	1983	8	25,032	5	17,142	216	68-123	10-12
North Kildinskoye	Barents Sea	1985	3	9,333	1	3,326	275	230-280	11-12
Pomorskoye	Barents Sea	1985	1	2,750	1	2,750	20	20-26	4-5
North Gulyayevskoye	Barents Sea	1986	1	3,072	1	3,072	75	10-30	4-5
Shtokman	Barents Sea	1988	5	n/a	1	n/a	560	279-380	4-5
Prirazlomnoye	Pechora Sea	1989	5	n/a	1	n/a	60	19-20	4-5
Rusanovskoye	Kara Sea	1989	2	4,923	1	2,373	235	50-100	3-4
Ludlovskoye	Barents Sea	1990	3	9,038	2	4,968	755	200-240	10-12
Leningradskoye	Kara Sea	1990	2	4,955	1	2,453	125	80-165	3-4
Ledovoye	Barents Sea	1992	2	5,000	1	2,500	700	200-280	10-12
Total			32	n/a	15	n/a			

Source: Company reports

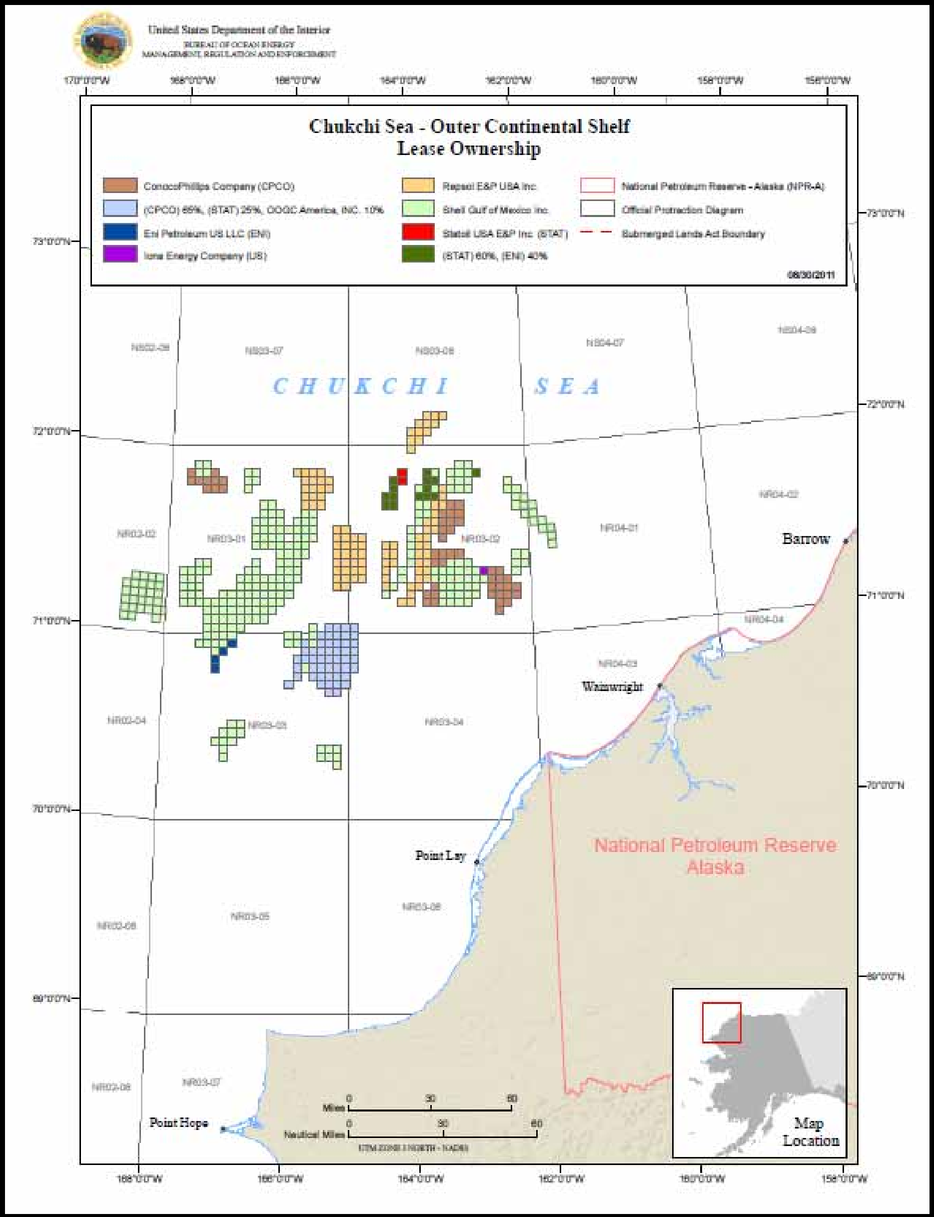
Beaufort Sea leases are held by the Majors but fallen out of favour in recent rounds

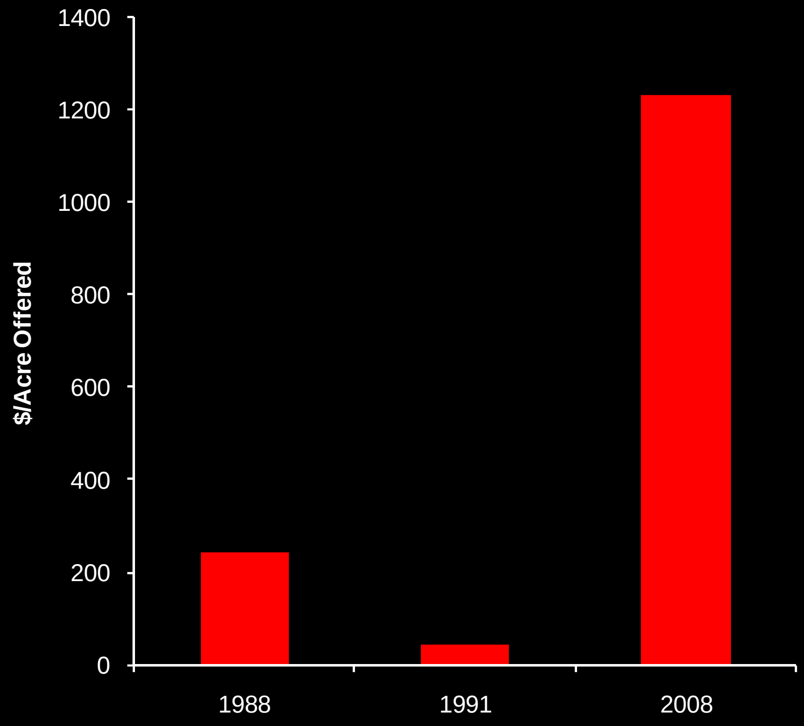




Source: BOEMRE

Chukchi Sea leases were heavily competed for in 2008

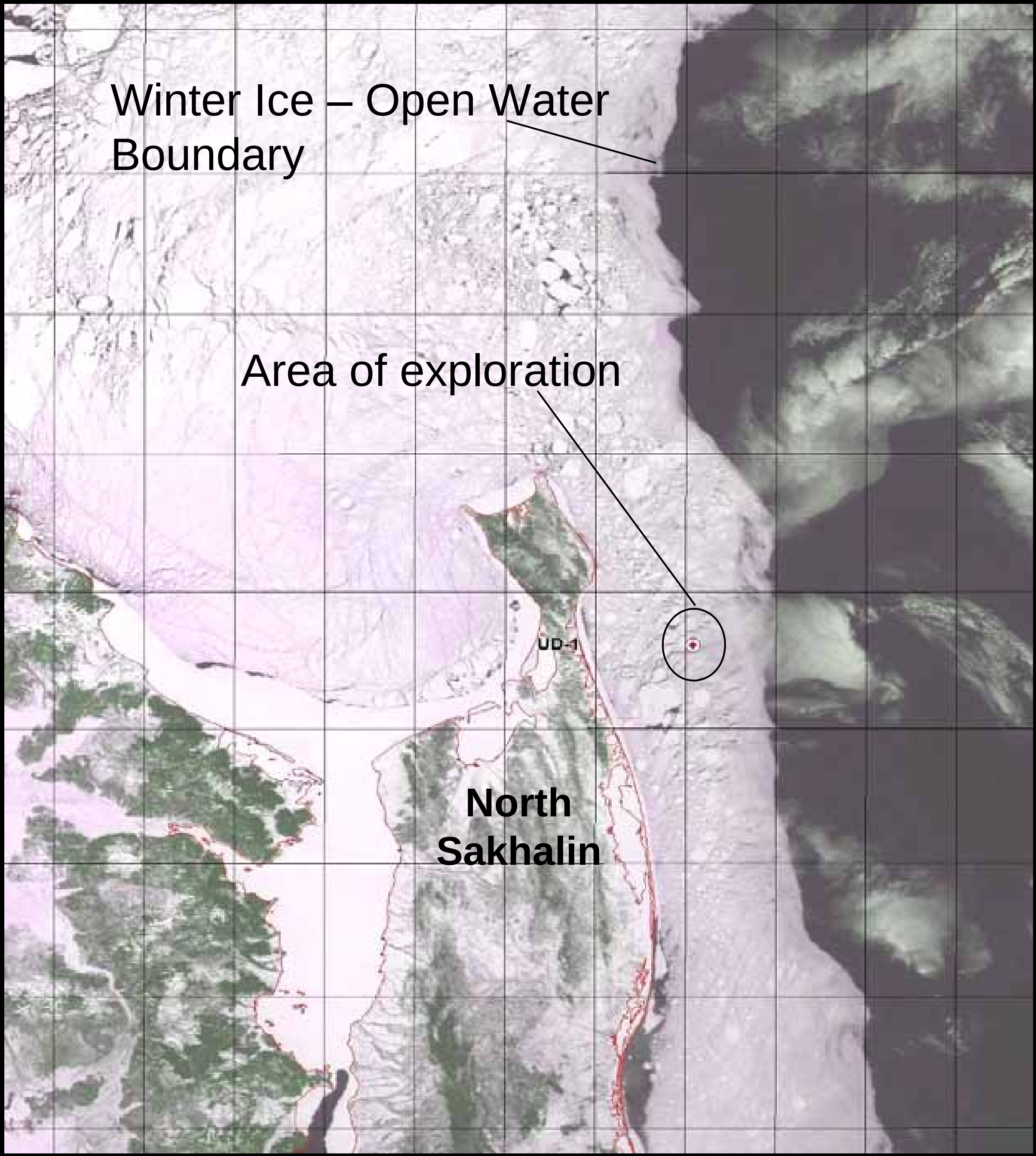




Source: BOEMRE

What are the challenges?

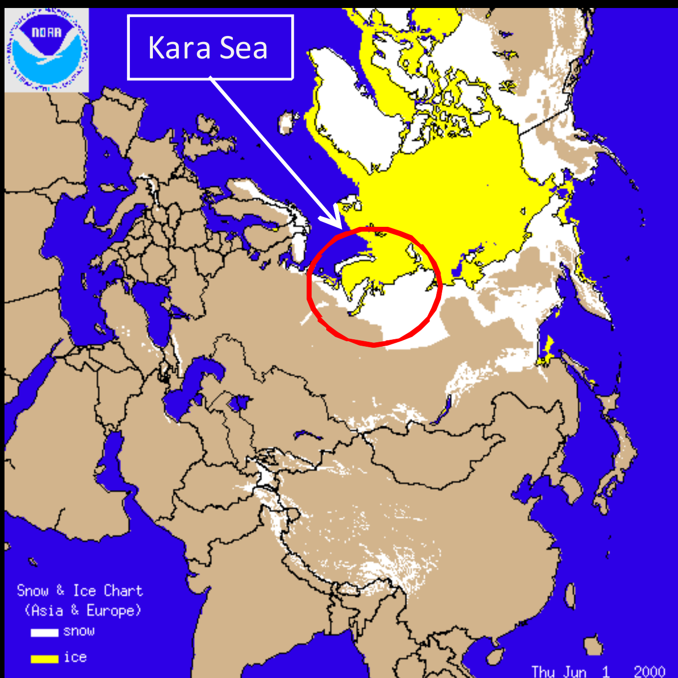
Obviously the ice – proposed location for an wildcat well offshore Sakhalin



Source: BP

Despite global warming access to the Kara Sea is not any easier

1st June 2000



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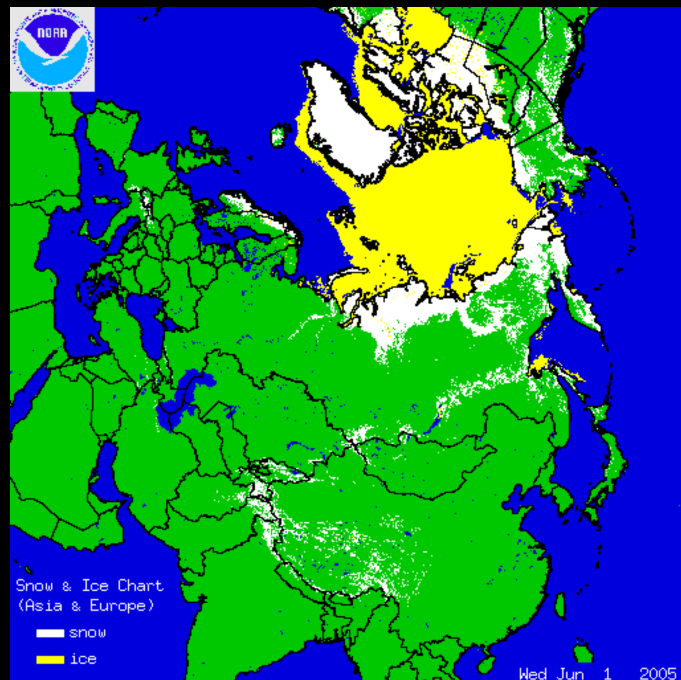
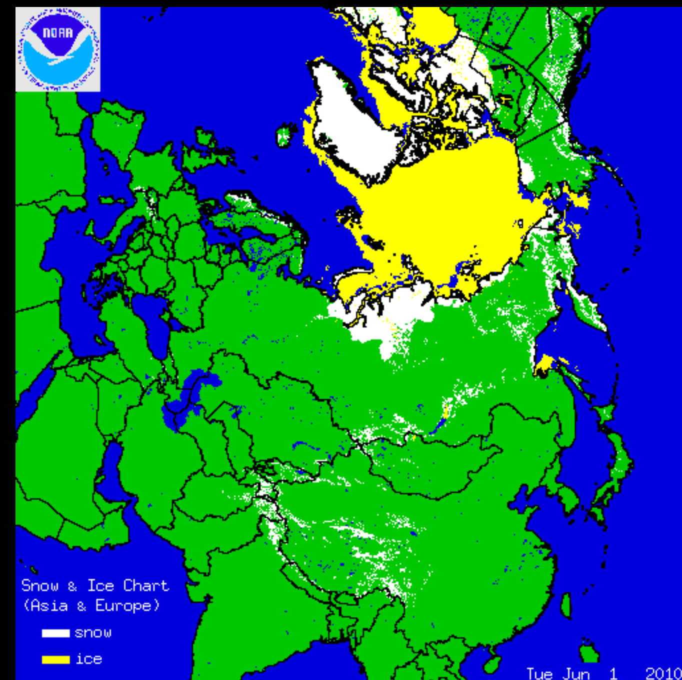
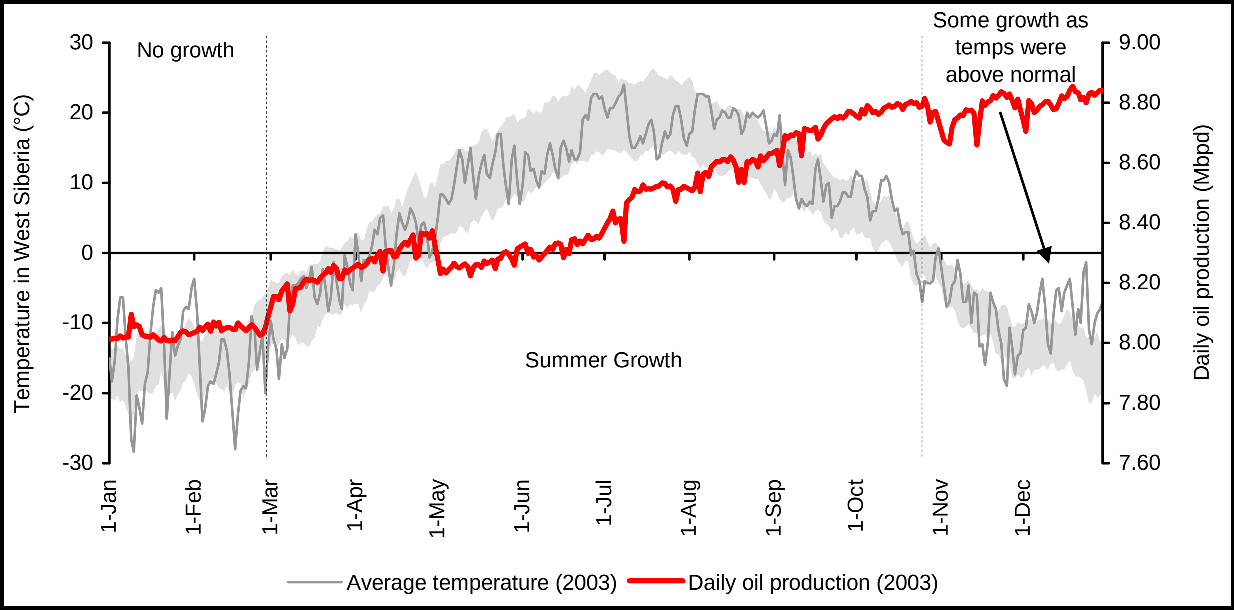


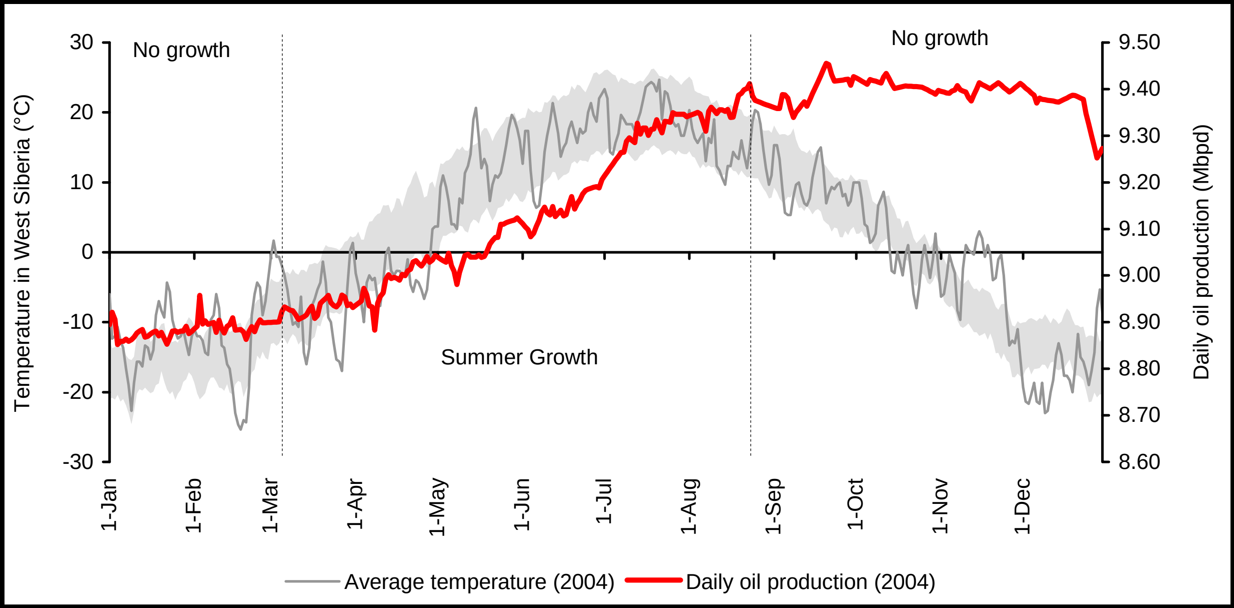
1st June 2010



Source: NOAA and Bernstein estimates

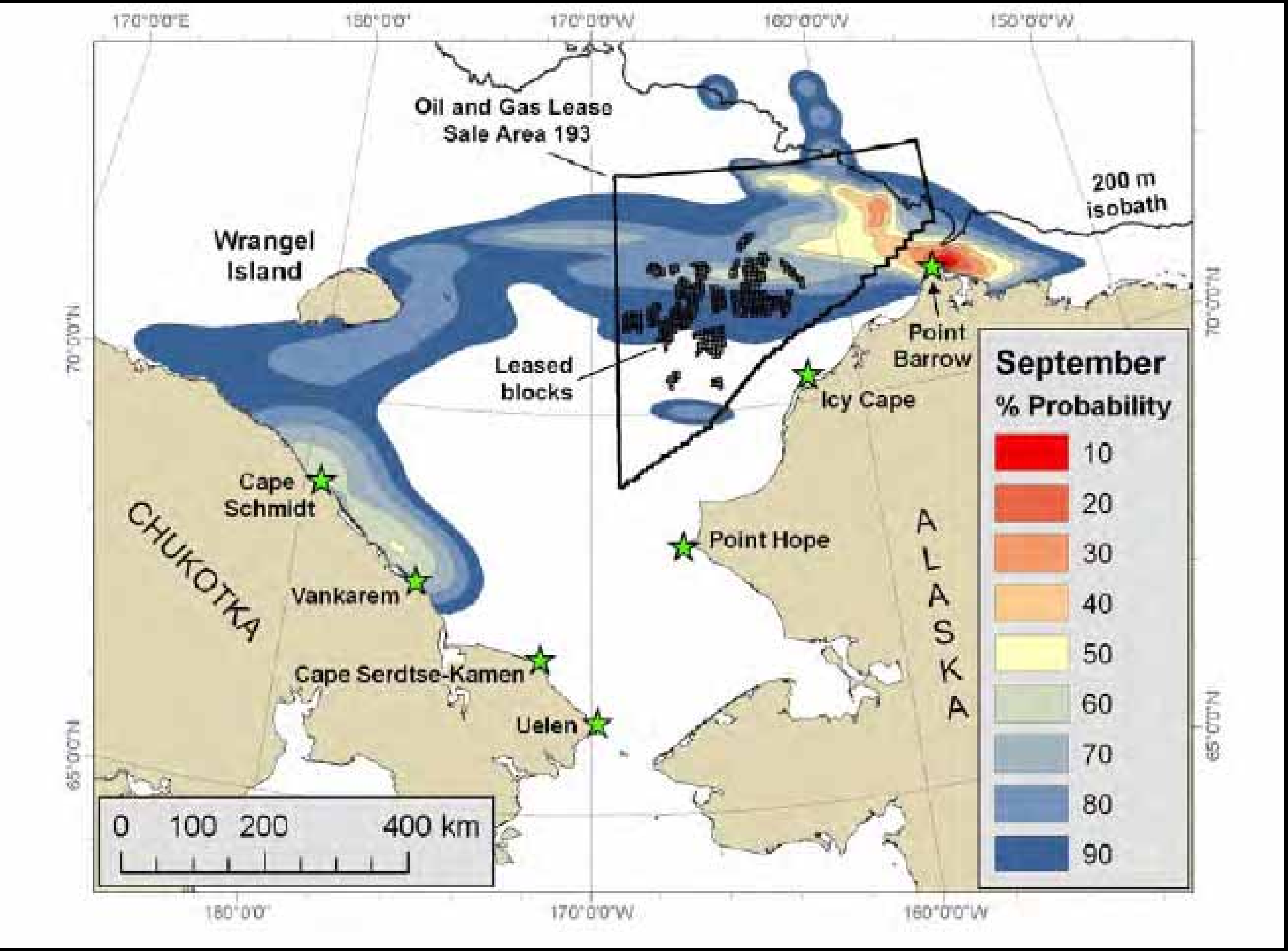
Variable weather impacts production performance





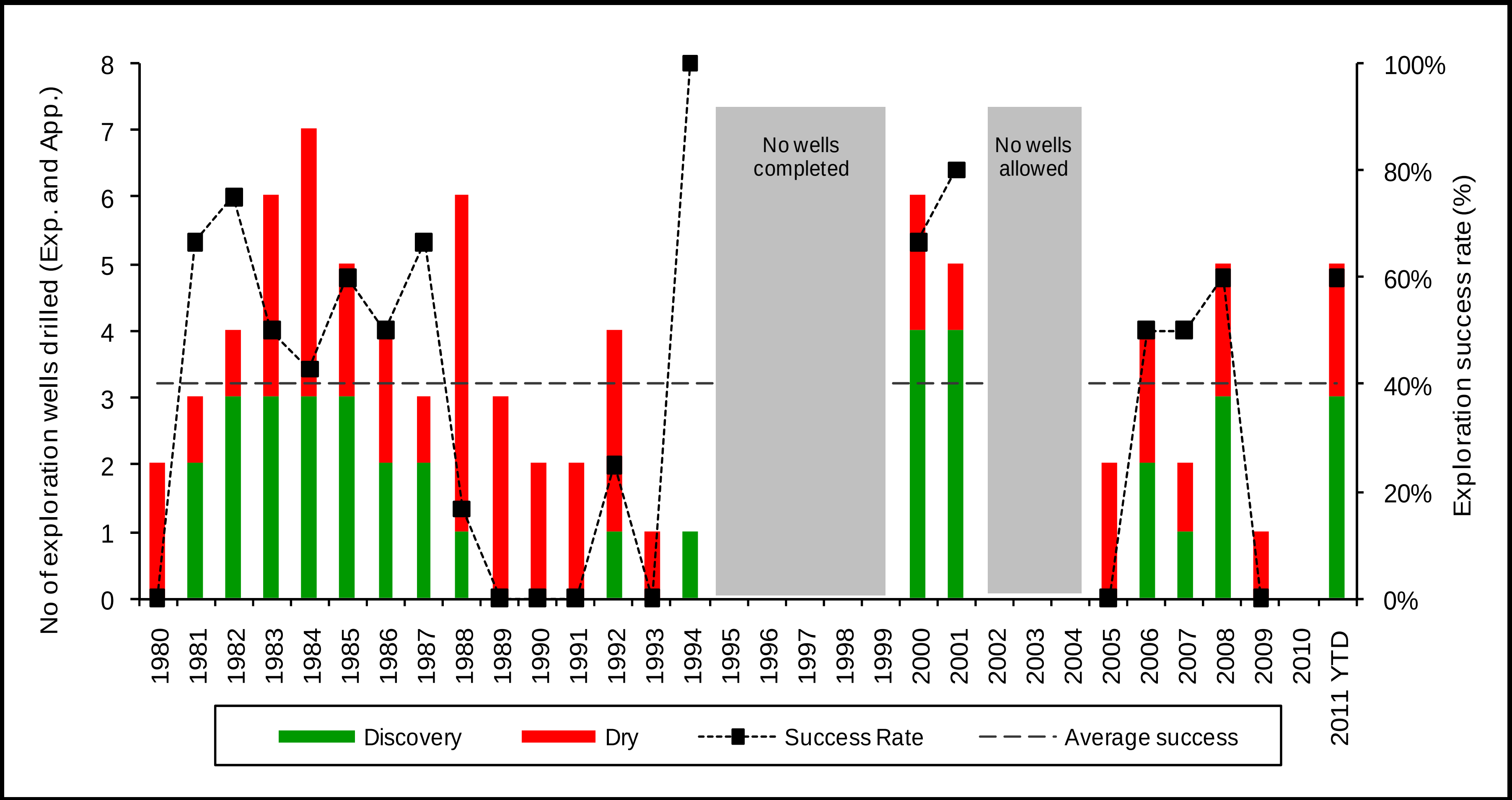
Source: NefteCompass and Bloomberg

Planning for the presence of Bowhead whales



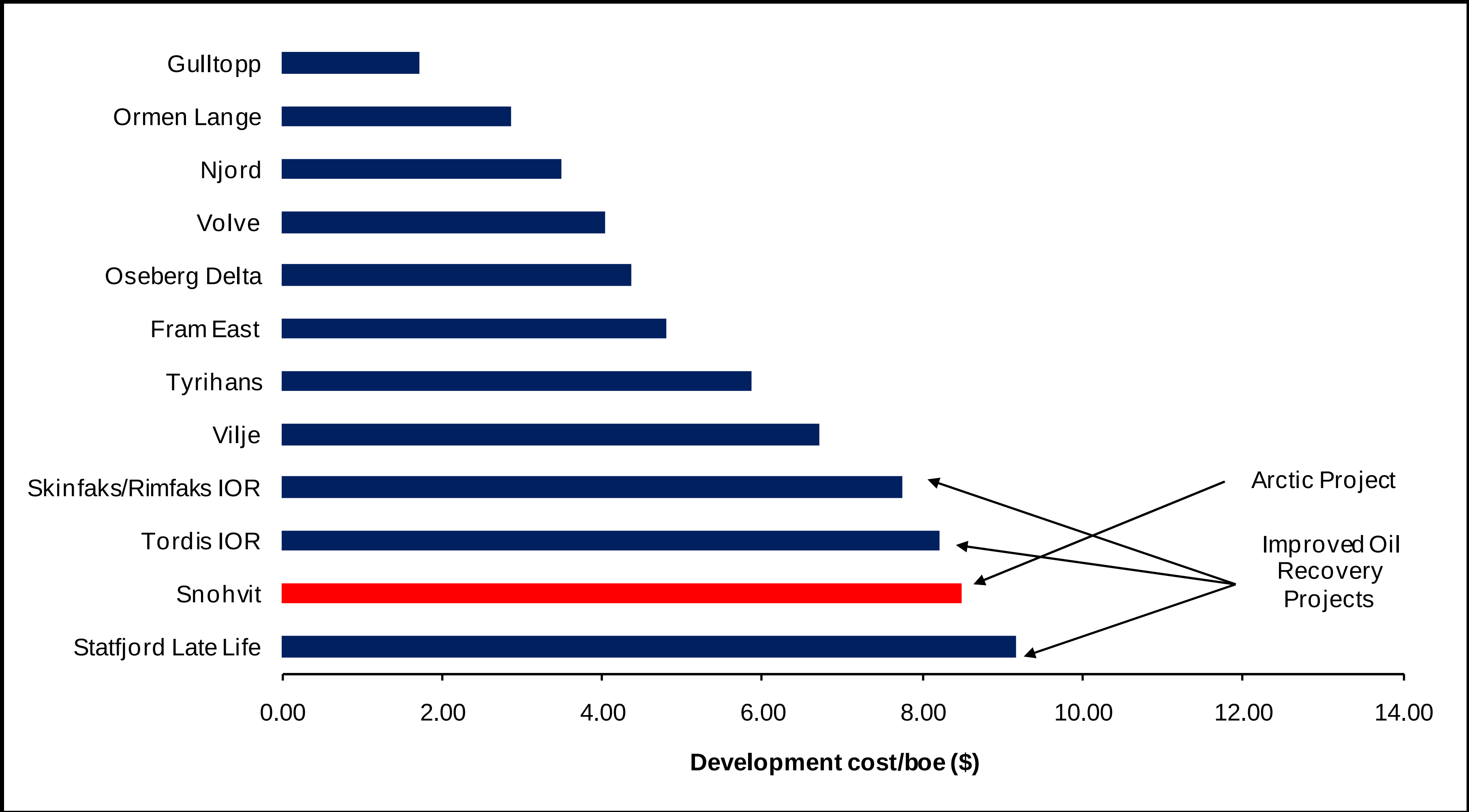
Source: BOEMRE

Arctic Barents Sea - 83 wells in 31 years, 38 successes but only 1 producing field so far



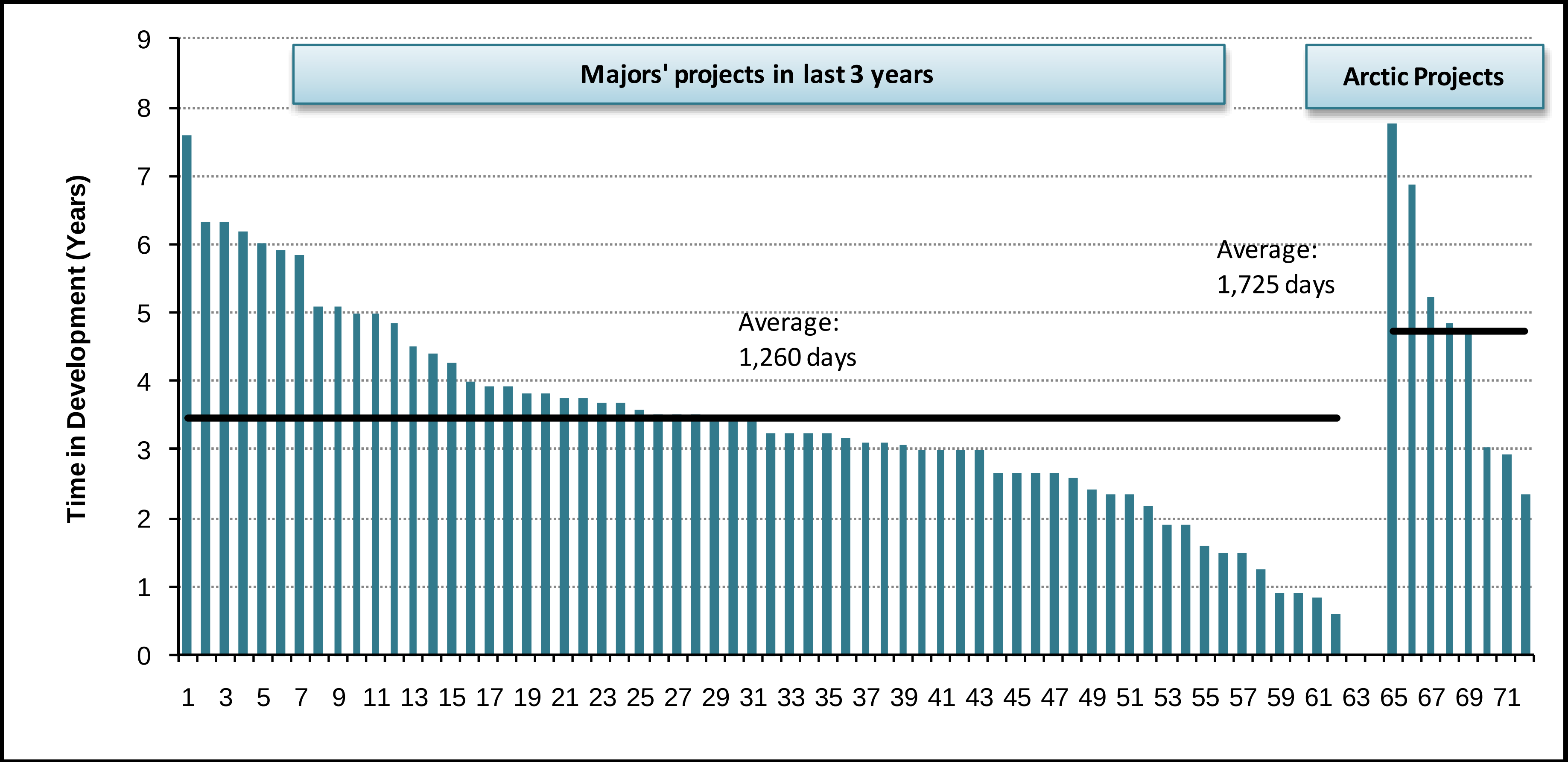
Source: NPD and Bernstein estimates

Development costs will be at the high end and in line with EOR projects



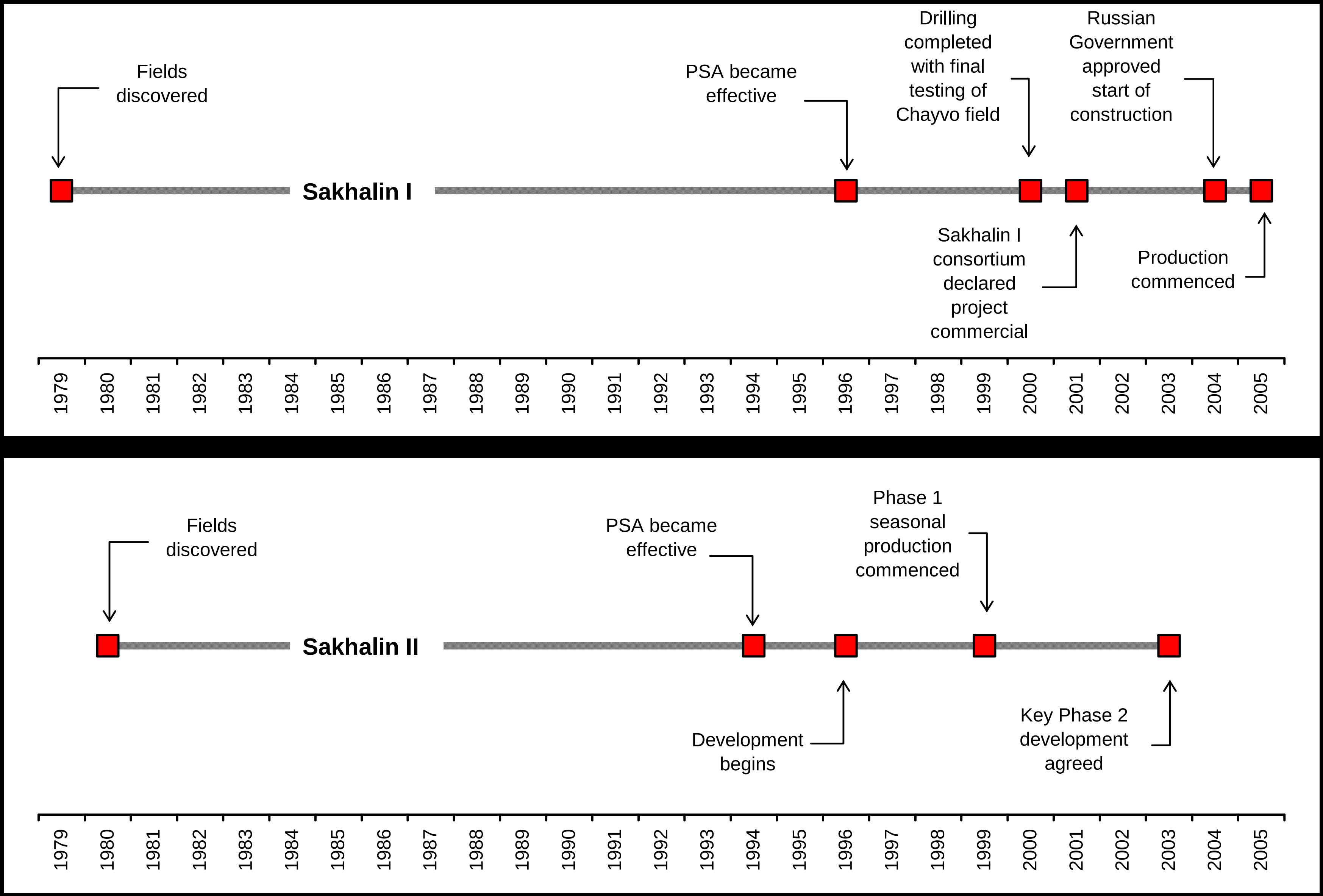
Source: Company reports and Bernstein estimates

Arctic projects take longer to develop than the Majors average development time



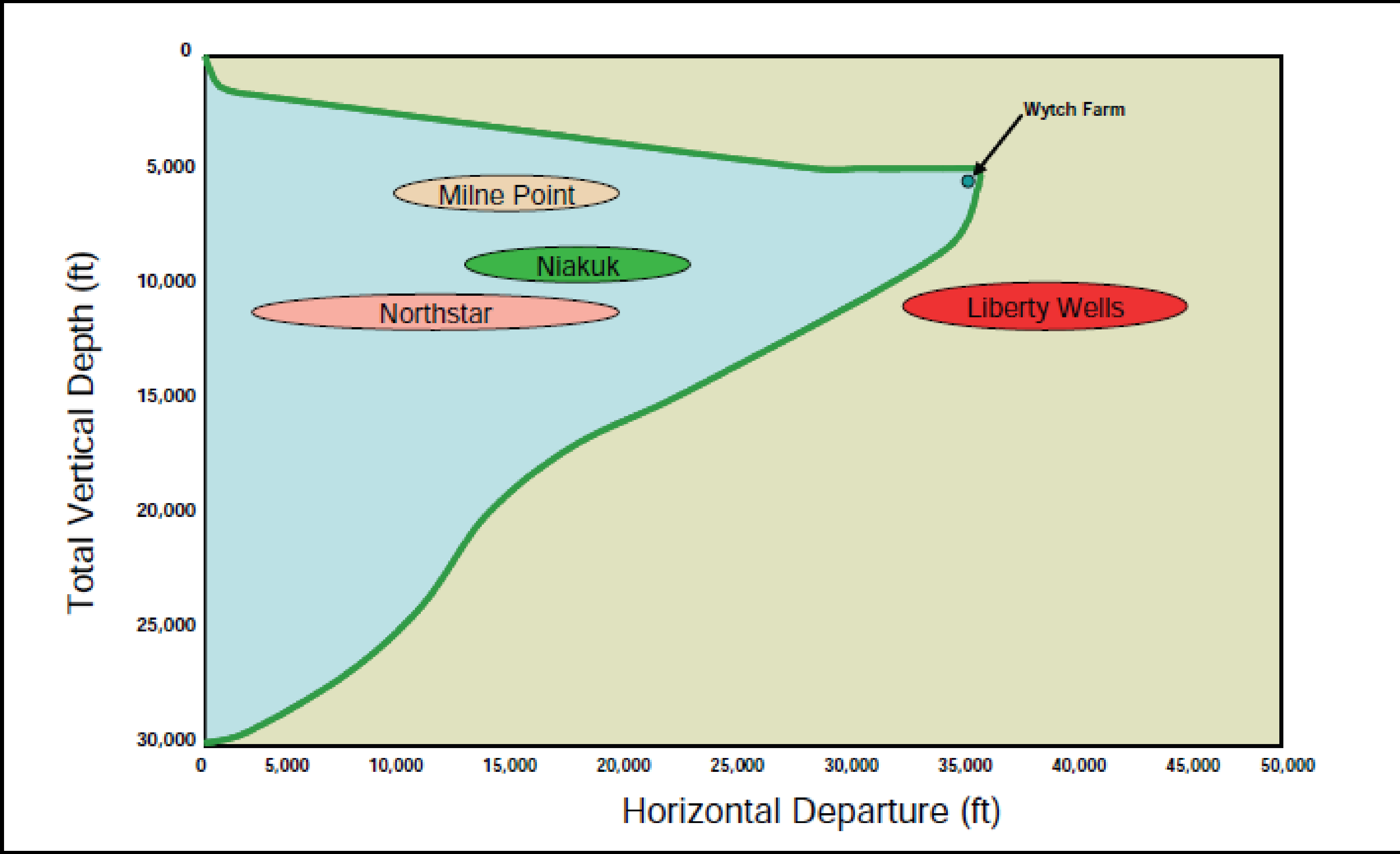
Source: Company reports and Bernstein estimates

Time period from discovery to first production offshore Sakhalin



Source: Company reports

Liberty field offshore Alaska has 105Mbbls but needs a new development concept versus existing North Slope fields



Source: BP

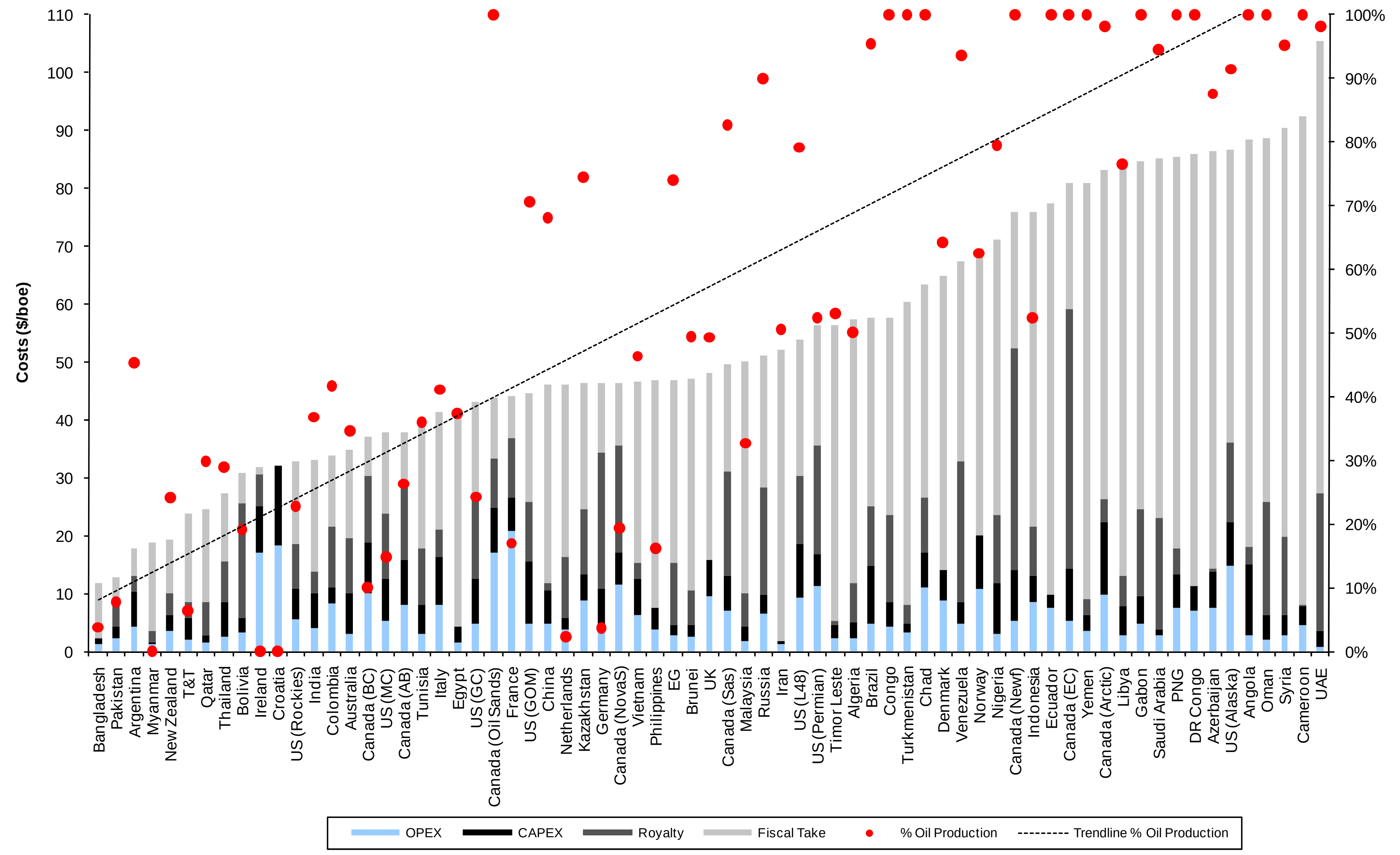
This is a recurring problem – development design and design which causes costs to move higher

Engineering Project	Location	Client	Project Description	Finish Date
Shtokman Field Constructability Study	Barents Sea, Russia	Confidential	Constructability study for 550 km long pipeline from Shtokman field to the Russian mainland with diameters up to 48-inch and water depths up to 375 meters.	2005
Shtokman Field 42-inch Export Riser Conceptual Design	Barents Sea, Russia	ConocoPhillips	Carried out a study to investigate the options for a large diameter gas riser at a TLP type production platform.	1992
Shtokman Field Offshore Pipelines Field Feasibility	Barents Sea, Russia	Wartsila Project Export & Finnish Barents Group	Undertook technical and cost studies to determine the feasibility of constructing a pipeline from the Shtokman Field in the Barents Sea to markets in Western and Central Europe.	1990

Development Infrastructure	1994	2007	2011
Ice-resistant platforms	2	3	3
Sub-sea wells	48	40	68
Sub-sea pipeline and cable (km)	25	n/a	n/a
Sub-sea condensate storage ('000m3)	30	n/a	n/a
Pipeline transport (km)	535	555	555
Pipeline thickness (inch)	42	42	42
Total Cost	$6Bn	$20Bn	~$40Bn

Source: Intec Engineering , Company reports and Bernstein estimates

Fiscal takes will be crucial to make Arctic any developments viable



Source: Wood Mackenzie, Company reports and Bernstein estimates

Conclusions

1. Arctic geology appears favourable for exploration

2. Global oil & gas supply need further large scale discoveries as current deepwater discoveries will only equate to ~20% of total production

3. Development costs will be at the high side of the industry range

4. Development times are likely to disappoint in the Arctic

5. Local tax regimes must be favourable given the additional constraints from Mother Nature but also if the H/C is gas

6. Given these issues we don’t include any new Arctic oil in our supply forecasts this decade

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