Introduction to the IOOA and review of seismic interactions with fish

Presentation to the Pelagic Advisory Council
21 April 2015, Bilbao
Gareth Parry – IOOA Environmental Subcommittee

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Irish Offshore Operators' Association (IOOA)

- Founded in 1995, IOOA is the representation organisation for the Irish offshore oil and gas industry
- Currently 15 members representing multinational and Irish petroleum exploration companies who hold licensing authorisations in the Irish offshore
- Members of IOOA are active in seismic and other operational activities in the Irish offshore
- IOOA member companies

AzEire Petroleum
Cairn Energy Plc
Eni UK Ltd
Faroe Petroleum
Fastnet Oil & Gas (Ireland) Ltd
PSE Kinsale Energy Ltd
Kosmos Energy
Lansdowne Oil & Gas Plc
Providence Resources Plc
Repsol
San Leon Energy Plc
Serica Energy
Shell E&P Ireland Ltd
Statoil
Woodside Energy (Ireland) Pty Ltd

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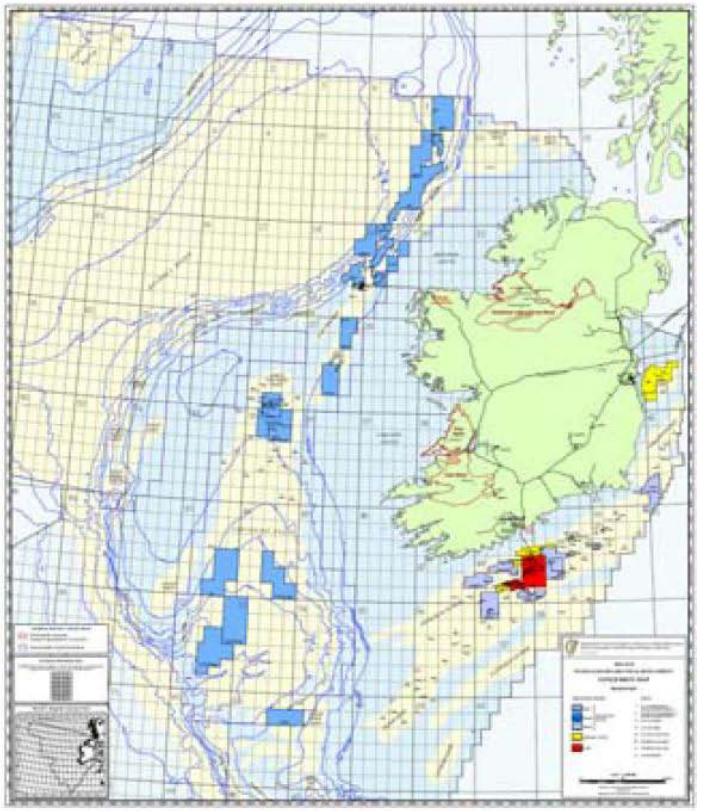
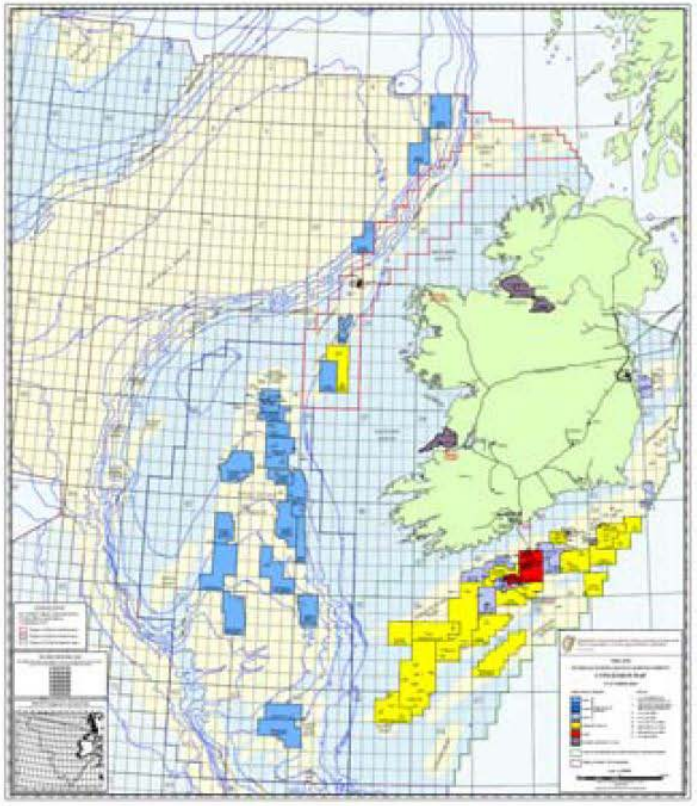
Concession maps

March 2010



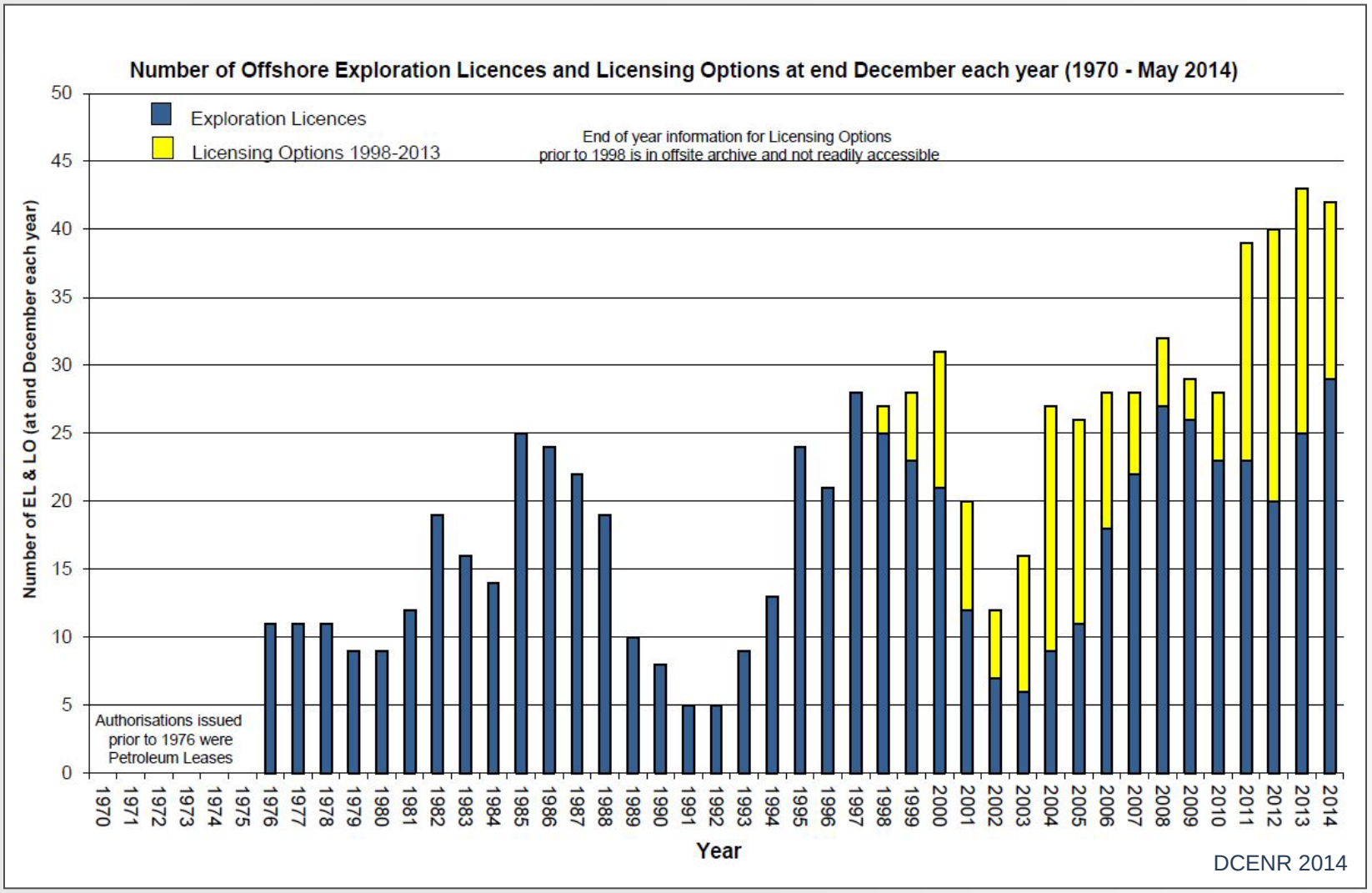
October 2014



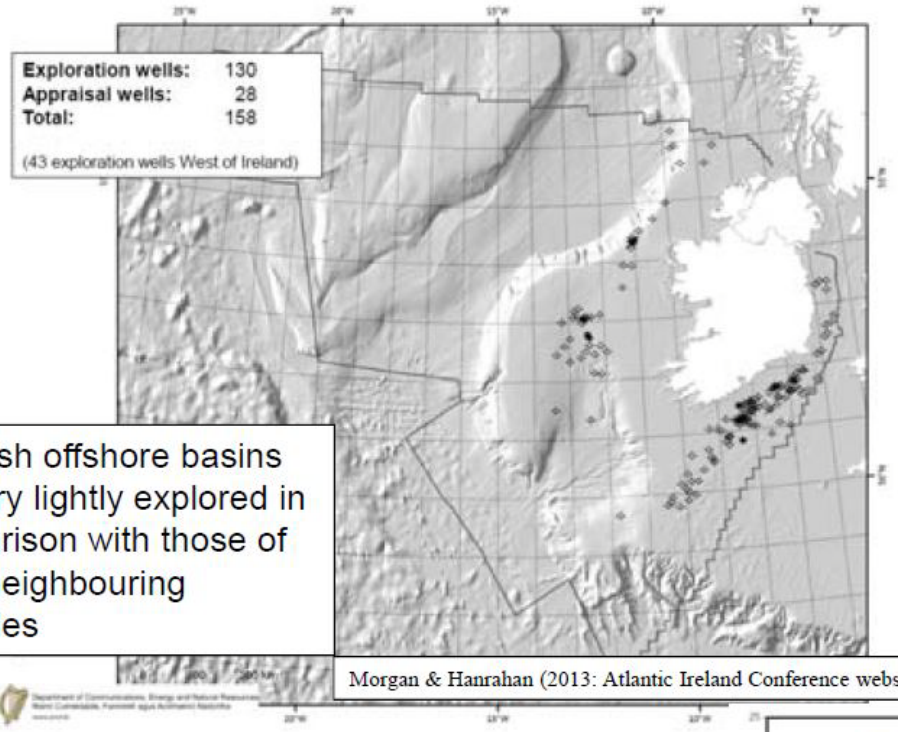
During the past ~four years there has been an increase licenses/licensing options in the Porcupine and Celtic Sea basins and a decrease in the Erris, Donegal and Rockall basins.

DCENR 2014

Irish offshore authorisations



EXPLORATION AND APPRAISAL WELLS



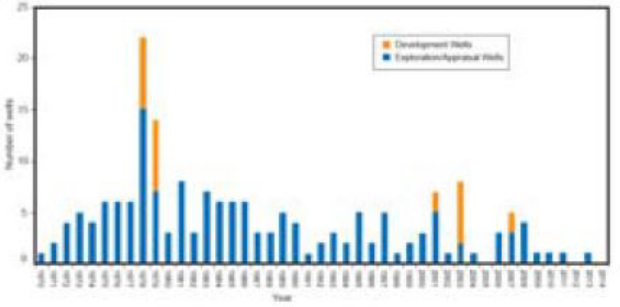
Morgan & Hanrahan (2013: Atlantic Ireland Conference website)

The Irish offshore basins are very lightly explored in comparison with those of most neighbouring countries

E&A WELLS

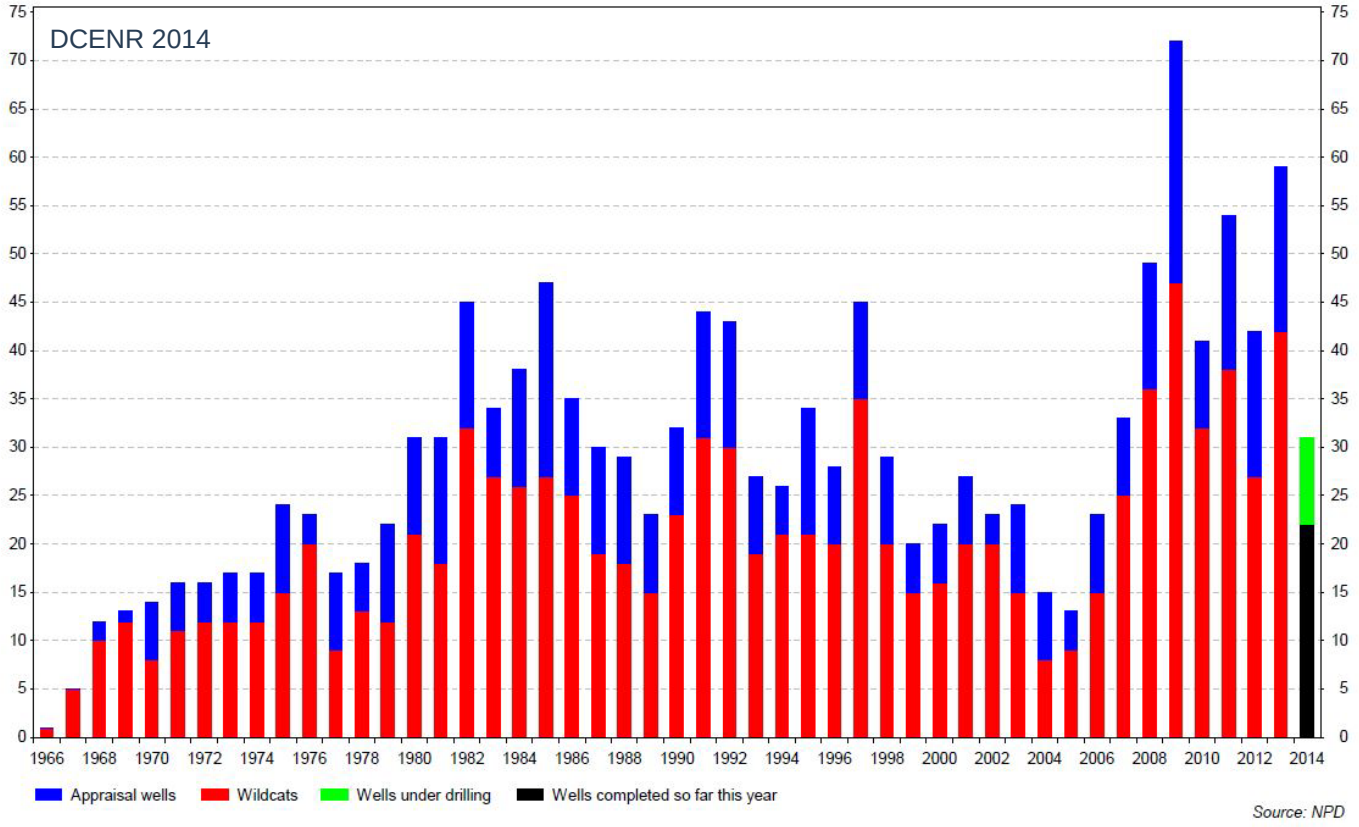
Kish Bank Basin:	4
Central Irish Sea:	5
Goban Spur:	1
Celtic Sea basins:	85
Fastnet Basin:	12
Porcupine Basin:	31
Slyne Basin:	10
Erris Basin:	4
Donegal Basin:	2
Rockall Basin:	4

The number of E&A wells drilled per annum in the Irish offshore is very low, and is significantly lower than it was during the 1970s and 1980s.



DCENR 2014

Exploration and appraisal wells on the Norwegian Continental Shelf (NCS)



In contrast to Ireland, the numbers of wells drilled on the Norwegian Continental Shelf have remained high in the past 5 years.

This reflects the perceived levels of risk and prospectivity of the regions.

Operating window

Summary

Input Model	Wave 8G	Offshore location	52° 34' 35"N, 12° 22' 14"W 50° 49' 11"N, 12° 13' 0"W	variable(s)	Significant wave height
Time range	1991-01-01 2013-03-31	Period of year	All year		

Download data

52° 34' 35"N, 12° 22' 14"W

All year

Monthly distribution of significant wave height (m)

meter	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR	Cumul
0 - 2	7.5	7.4	13.1	21.5	41.3	49.0	52.2	51.2	33.2	17.9	7.5	6.4	26.6	100.0
2 - 4	31.3	39.4	47.9	57.1	48.8	46.8	44.1	45.4	51.5	51.5	44.9	41.8	45.8	74.4
4 - 6	34.8	33.2	27.6	17.5	9.7	4.0	3.5	3.3	13.8	24.0	34.2	31.7	19.8	28.6
6 - 8	18.1	13.7	8.9	2.8	0.9	0.3	0.08	0.1	1.4	5.5	10.9	14.0	6.4	8.8
8 - 10	6.2	4.9	1.9	0.8	0.2	0.00	0.00	0.00	0.06	1.1	1.8	4.7	1.8	2.4
10 - 12	1.9	1.2	0.5	0.3	0.00	0.00	0.00	0.00	0.00	0.07	0.4	1.1	0.5	0.6
12 - 14	0.2	0.2	0.09	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.3	0.08	0.09
14 - 16	0.03	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.01	0.02
> 16	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	
Dataset min.	1.0	0.8	1.0	0.8	0.6	0.7	0.7	0.8	0.8	0.6	1.0	1.1	0.6	
Dataset max.	17.3	13.4	15.0	12.8	9.2	7.8	6.3	7.2	8.4	11.6	13.4	15.6	17.3	
Dataset avg.	4.8	4.5	3.8	3.1	2.5	2.2	2.1	2.2	2.7	3.4	4.1	4.5	3.3	

50° 49' 11"N, 12° 13' 0"W

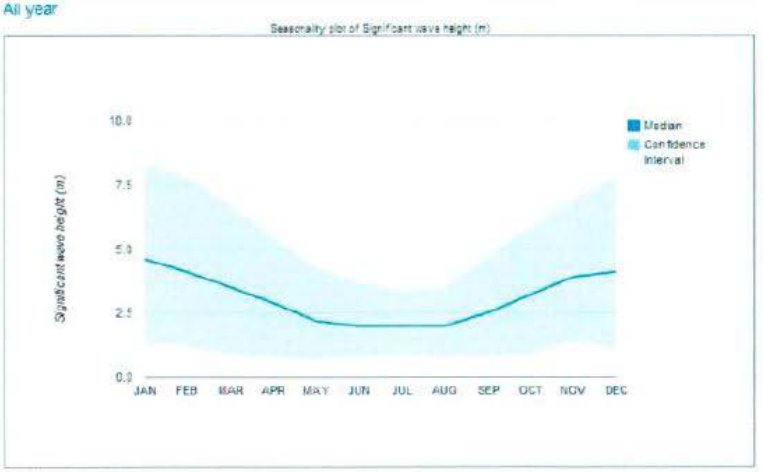
All year

Monthly distribution of significant wave height (m)

meter	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR	Cumul
0 - 2	6.4	7.9	12.4	20.7	40.4	50.6	54.2	55.2	34.6	17.9	8.6	5.8	26.1	100.0
2 - 4	34.2	43.7	50.9	58.8	51.0	46.1	42.8	41.2	53.2	52.9	45.1	44.1	46.9	73.9
4 - 6	35.5	30.3	27.7	16.5	7.6	2.8	3.0	3.5	10.7	23.2	34.6	30.8	18.9	26.0
6 - 8	15.7	13.1	6.9	2.8	0.9	0.4	0.00	0.2	1.4	5.3	9.2	13.8	5.9	8.0
8 - 10	5.7	3.7	1.7	0.8	0.1	0.00	0.00	0.00	0.1	0.6	2.0	4.3	1.6	2.1
10 - 12	1.3	1.2	0.3	0.3	0.00	0.00	0.00	0.00	0.00	0.07	0.4	1.1	0.4	0.5
12 - 14	0.2	0.2	0.08	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.1	0.1	0.05	0.07
14 - 16	0.04	0.05	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.01	0.02
> 16	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	
Dataset min.	1.1	1.2	1.0	0.8	0.6	0.7	0.7	0.8	0.8	0.6	1.0	1.2	0.6	
Dataset max.	15.4	15.1	17.5	12.2	9.1	7.2	6.0	7.3	8.7	10.8	14.1	17.4	17.5	
Dataset avg.	4.7	4.3	3.7	3.1	2.5	2.2	2.1	2.1	2.7	3.4	4.0	4.4	3.3	

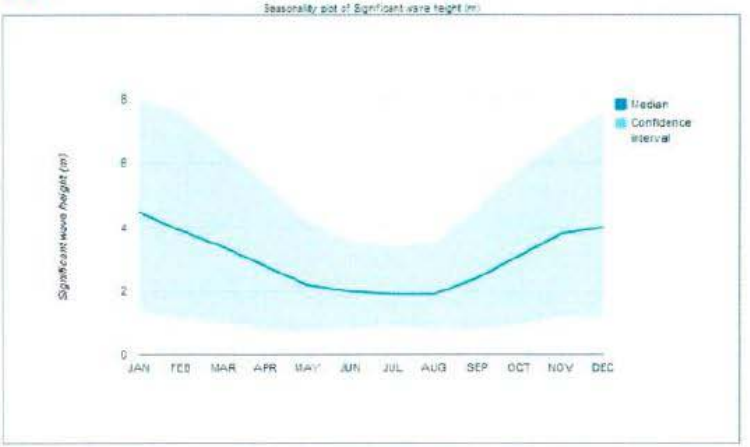
52° 34' 35"N, 12° 22' 14"W

All year

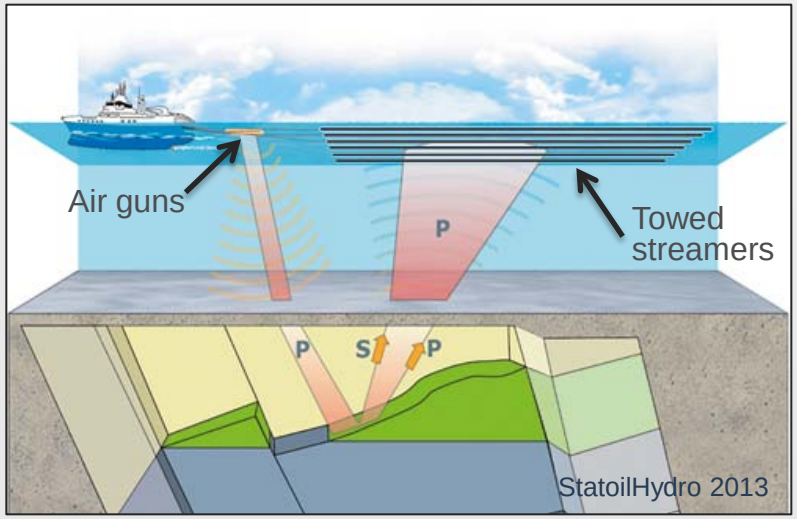


50° 49' 11"N, 12° 13' 0"W

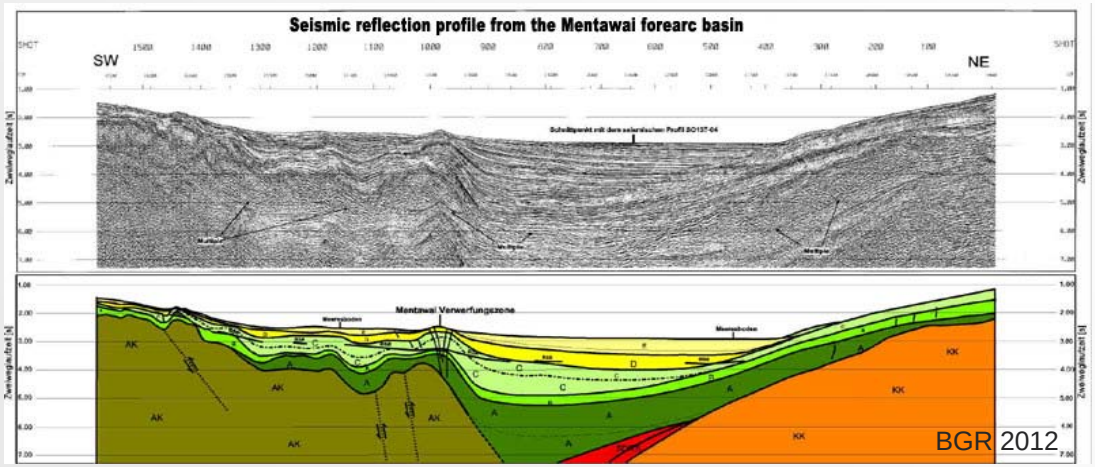
All year



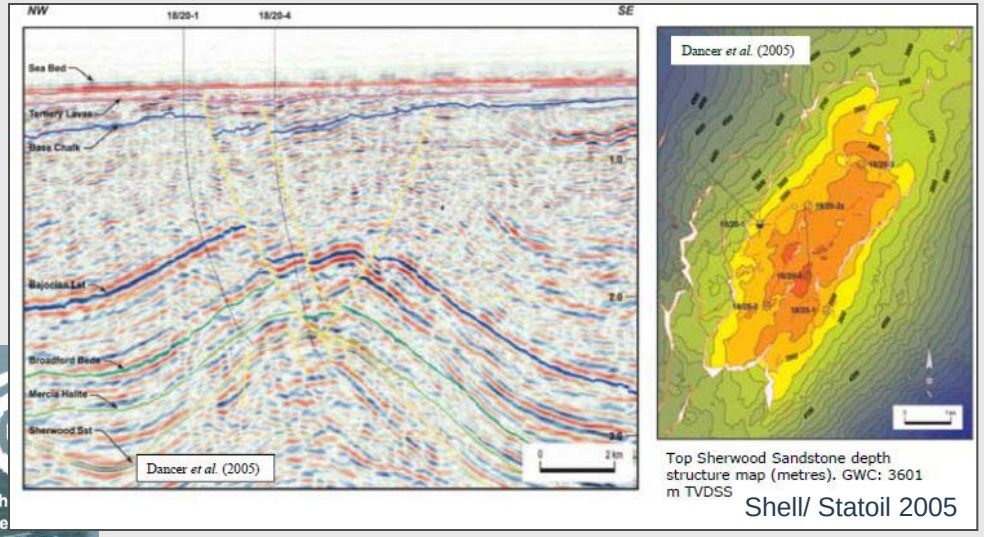
Marine seismic survey



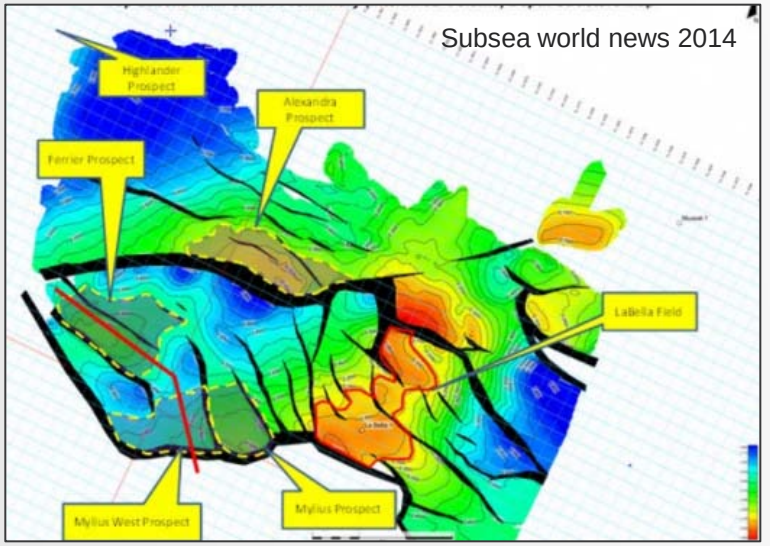
Marine seismic reflection



'Regional' 2D seismic line

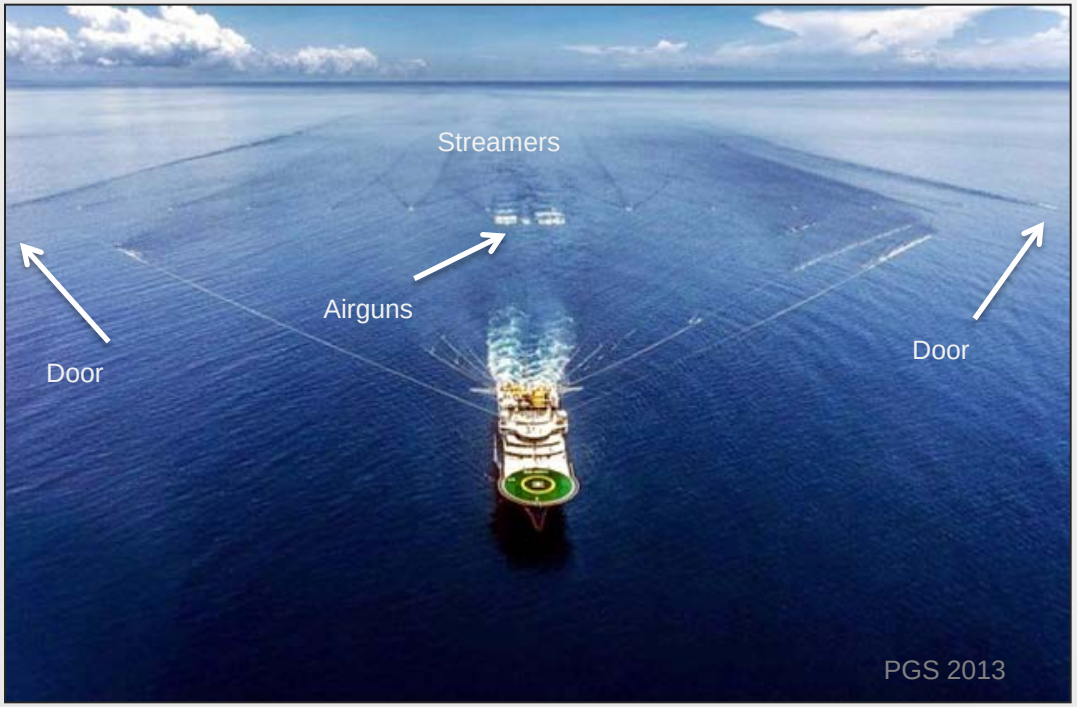


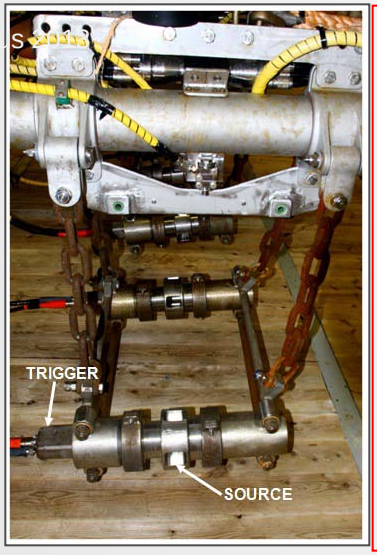
Shell/ Statoil 2005



Isopach 3D structure map

Seismic survey operations





Seismic operation assumptions:

- 90m seismic vessel.
- 1500m3 marine diesel.
- 3D survey with 4450 in^3 airgun array.
- 700m water depth
- 10 streamers 12 km long.
- Two support vessels.
- Option of bunkering at sea.

Underwater sound

- Underwater noise can be
  1. Single pulse (e.g. Single airgun, pile driving, sonic boom)
  2. Multiple pulse (e.g. Sequential airgun, active sonar and depth sounder)
  3. Nonpulse (e.g. Vessel cavitation, aircraft passing)
- Measurement
  1. **Source Level (SL**) or **Sound Pressure Level (SPL)** as it would measure 1m from the source in units of

     dB re 1 µPa

  2. **Received Level (RL)** or **Sound Exposure Level (SEL)** – is the Level (SEL) measure of energy as the "dB level of the time integral of the squared-instantaneous sound pressure normalised to a 1-s period". Units are

     dB re 1 µPa^2-s

*From Southall (2007)

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Anthropogenic noise and fish

Popper et al (2014*)

1. Mortality and potential injury
2. Impairment
   - Recoverable injury
   - Hearing - Temporary Threshold Shift (TTS)
   - Hearing - Masking
3. Behavioural


Source: Browse LNG Development


Source: Browse LNG Development


Source: Browse LNG Development

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*Popper, A.N., A.D. Hawkins, R.R. Fay, D.A. Mann, S. Bartol, T.J. Carlson, S. Coombs, W.T. Ellison, R.L. Gentry, et al. 2014. Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report prepared by ANSI-Accredited Standards Committee S3/SC1 and registered with ANSI. SpringerBriefs in Oceanography, vol. ASA S3/SC1.4 TR-2014. ASA Press. 87 pp.

Acoustic impact criteria – fish

Popper et al (2014*) thresholds for **fish**

*Popper, A.N., A.D. Hawkins, R.R. Fay, D.A. Mann, S. Bartol, T.J. Carlson, S. Coombs, W.T. Ellison, R.L. Gentry, et al. 2014. Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report prepared by ANSI-Accredited Standards Committee S3/SC1 and registered with ANSI. SpringerBriefs in Oceanography, vol. ASA S3/SC1.4 TR-2014. ASA Press. 87 pp.

Type of Animal	Mortality and potential mortal injury	Impairment			Behavior
		Recoverable injury	TTS	Masking	
Fish: no swim bladder	> 219 dB SEL_{cum} or > 213 dB peak	> 216 dB SEL_{cum} or > 213 dB peak	>> 186 dB SEL_{cum}	(N) Low (I) Low (F) Low	(N) High (I) Moderate (F) Low
Fish: swim bladder is not involved in hearing	> 210 dB SEL_{cum} or > 207 dB peak	> 203 dB SEL_{cum} or > 207 dB peak	>> 186 dB SEL_{cum}	(N) Low (I) Low (F) Low	(N) High (I) Moderate (F) Low
Fish: swim bladder involved in hearing	> 207 dB SEL_{cum} or > 207 dB peak	> 203 dB SEL_{cum} or > 207 dB peak	>> 186 dB SEL_{cum}	(N) Low (I) Low (F) Moderate	(N) High (I) High (F) Moderate
Eggs and Larvae	> 210 dB SEL_{cum} or > 207 dB peak	(N) Moderate (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low

Notes: peak SPL in dB re 1 µPa; SEL in dB re 1 $\mu Pa^2 \cdot s$. Relative risk (high, moderate, low) is given for animals at three distances from the source defined in relative terms as near (N), intermediate (I), and far (F).

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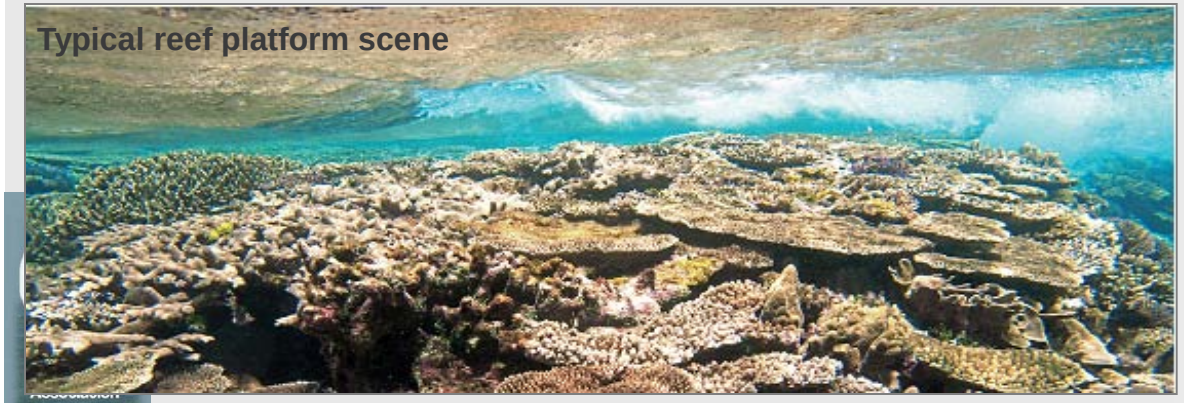
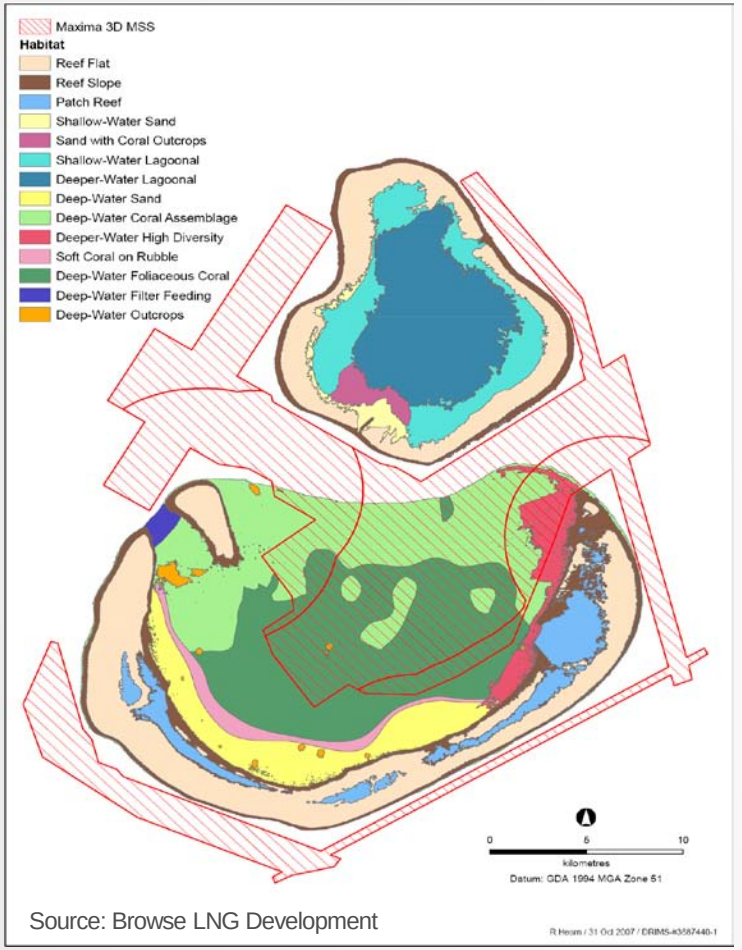
Case Study - Scott Reef, NW Australia

- Scott Reef is a large emergent shelf atoll (50 km by 30 km)on the outer edge of the continental shelf.
- More than 30,000 different species.
- High diverse coral reef with many site-attached fish between 1 and 70 metres water depth
- Reef fishes unlikely to flee where reliant on benthic habitat (‘site-attached’)
- Uncertainty in potential for impact on fish hearing
- Subsequent potential for population-level effects uncertain
- Other physiological effects on fish (sub-lethal, hearing)



Source: Browse LNG Development



Source: Browse LNG Development

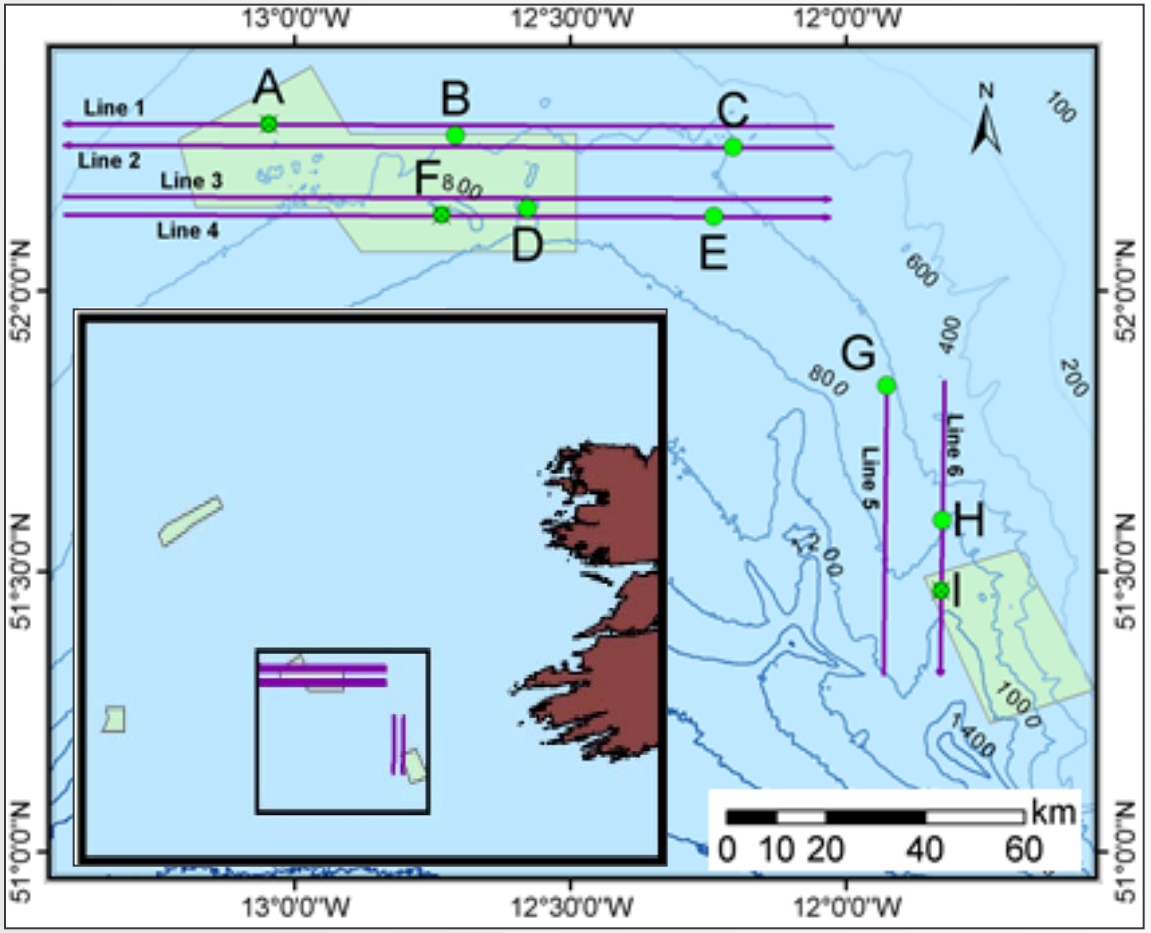
Quantifying Seismic Impact on a Sensitive Marine Environment (Tropical Reef)

- World-first independent identification and evaluation of potential impacts from a seismic survey
- A major field verification study to validate impact predictions and modelling included in the impact assessment - €7M
- Program designed and overseen by independent researchers from eight Universities
- **Fish behaviour & specific acoustic impacts - NONE**
  - No lethal effects, Low level behavioural responses, return to normal feeding behaviour within 20 minutes of survey vessel passing
- **Fauna and fish abundance and diversity and coral impacts - NONE**
  - No fauna mortality observed that could be reasonably attributed to air gun emissions
  - No stress or damage to corals
- **Fish abundance and diversity impacts - NONE**
  - No fauna mortality
  - Underwater visual census and baited remote underwater videos used to cover range of habitats and species
  - No significant effect of the seismic survey on abundance or diversity detected

Source: Browse LNG Development

Offshore Ireland sound modelling

- Completed in 2014
- 4450 in^3 airgun array pressure specifications for towing depth of 7 m.
- Water depths between 400 and 900 m.
- Nine sites modelled, three primary focus sites.
- 6 selected locations along representative seismic track lines as sampled locations for the 24-hr cumulative noise modelling.
- Sound Pressure Levels (SPL) and Sound Exposure Levels (SELs) modelled.



Irish sound modelling summary

- Underwater sound levels (peak SPLs and SELs) from a 4450 in^3 airgun array were evaluated at three sites offshore of Ireland.
- Maximum modelled sound levels at the three sites were assessed against fish impact criteria, derived from peer-reviewed literature and from Maxima 3-D MSS study at Scott Reef, NW Australia.
- Modelled sound levels at the seafloor were below:
  - Popper et al, (2014) review stated criteria for fish mortality and fish hearing injury.
  - The sound levels reported in the distribution and abundance studies conducted at Scott Reef.

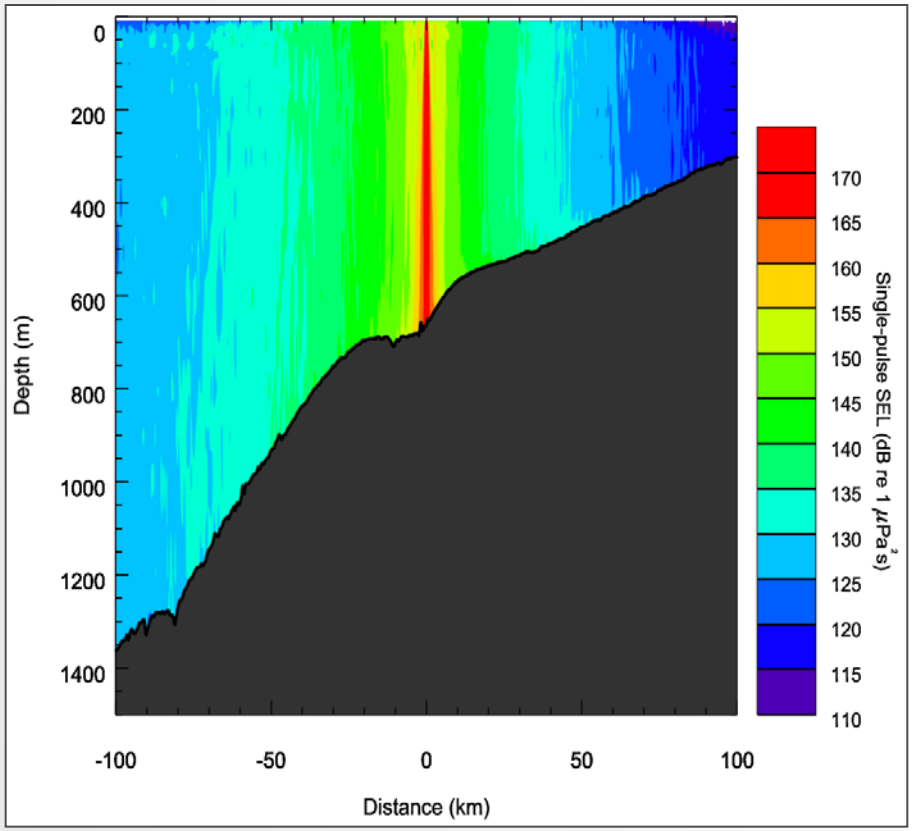


Figure. Single-pulse SEL versus range and depth for the airgun array . Levels are lower at equivalent ranges along the upslope (north) transect than along the downslope (south) transect because more energy is refracted into the sub-bottom for upslope propagation.

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Thank you – Questions???