Richard HALE
Director
EGS Survey Group
representing the
International Cable
Protection Committee

UN ICP on Oceans and the Law of the Sea

Underwater Sounds from Cable Operations

Slide 1

Sounds from Submarine Cable & Pipeline Operations

Richard Hale – Director, EGS Survey Group

representing the International Cable Protection Committee

Richard HALE
Director
EGS Survey Group
representing the
International Cable
Protection Committee

UN ICP on Oceans and the Law of the Sea

Underwater Sounds from Cable Operations

Slide 2

Introduction

- The socio-economic impact of submarine cables is strongly positive, consistent with the UN development goals.
- Submarine cable & pipeline operations introduce sound energy into the water column, both during the pre-installation survey and during installation. Afterwards, they are silent.
- Sounds come from survey and positioning instruments; from cable burial tools; and from the ship's engine & propeller.
- The sounds from survey and installation have low intensity and short duration compared with other offshore operations (e.g., oil-industry exploration; offshore construction). The sounds have minimal environmental impact.

Richard HALE
Director
EGS Survey Group
representing the
International Cable
Protection Committee

UN ICP on Oceans and the Law of the Sea

Underwater Sounds from Cable Operations

Slide 3

Socio-Economic Impacts of Submarine Cables

- The United Nations' Secretary-General reported that, "Submarine cables are critical communications infrastructure, being used for 98% of all international internet, data and telephone traffic… Submarine cables are recognized as vitally important to the global economy." (1)
- In low- and middle-income countries, a World Bank study indicated that a 10% increase in broadband penetration results in a 1.38% increase in GDP growth. (2)
- Assessing socio-economic progress in terms of the UN's Sustainable Development Goals (3) requires exchange of scientific, cultural, environmental and economic information from around the globe. Functioning as the backbone of the international telecommunications system, submarine cables are a fundamental component of the critical global infrastructure. (4)

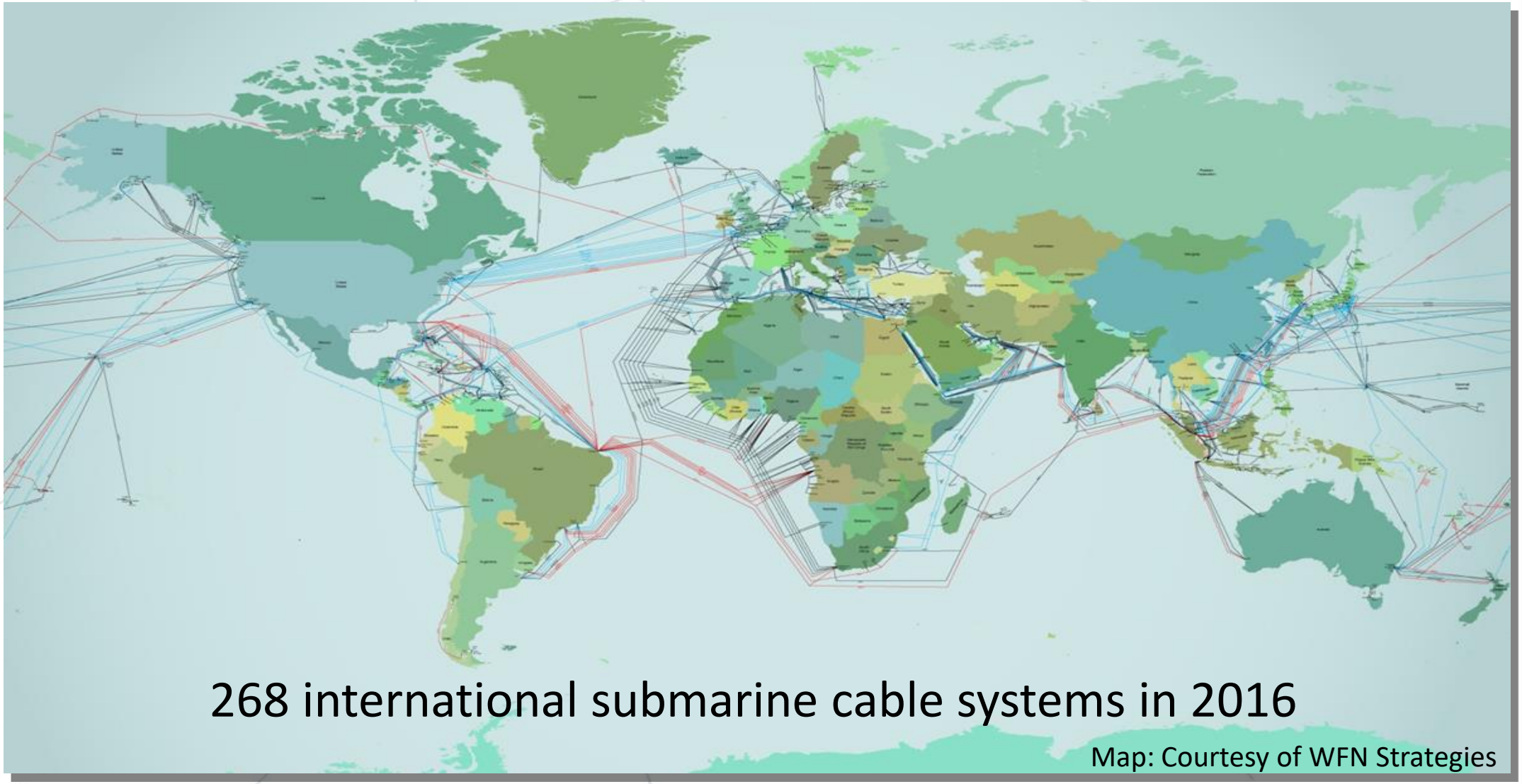
Richard HALE
Director
EGS Survey Group
representing the
International Cable
Protection Committee

UN ICP on Oceans and the Law of the Sea

Underwater Sounds from Cable Operations

Slide 4

International submarine cables



268 international submarine cable systems in 2016

Map: Courtesy of WFN Strategies

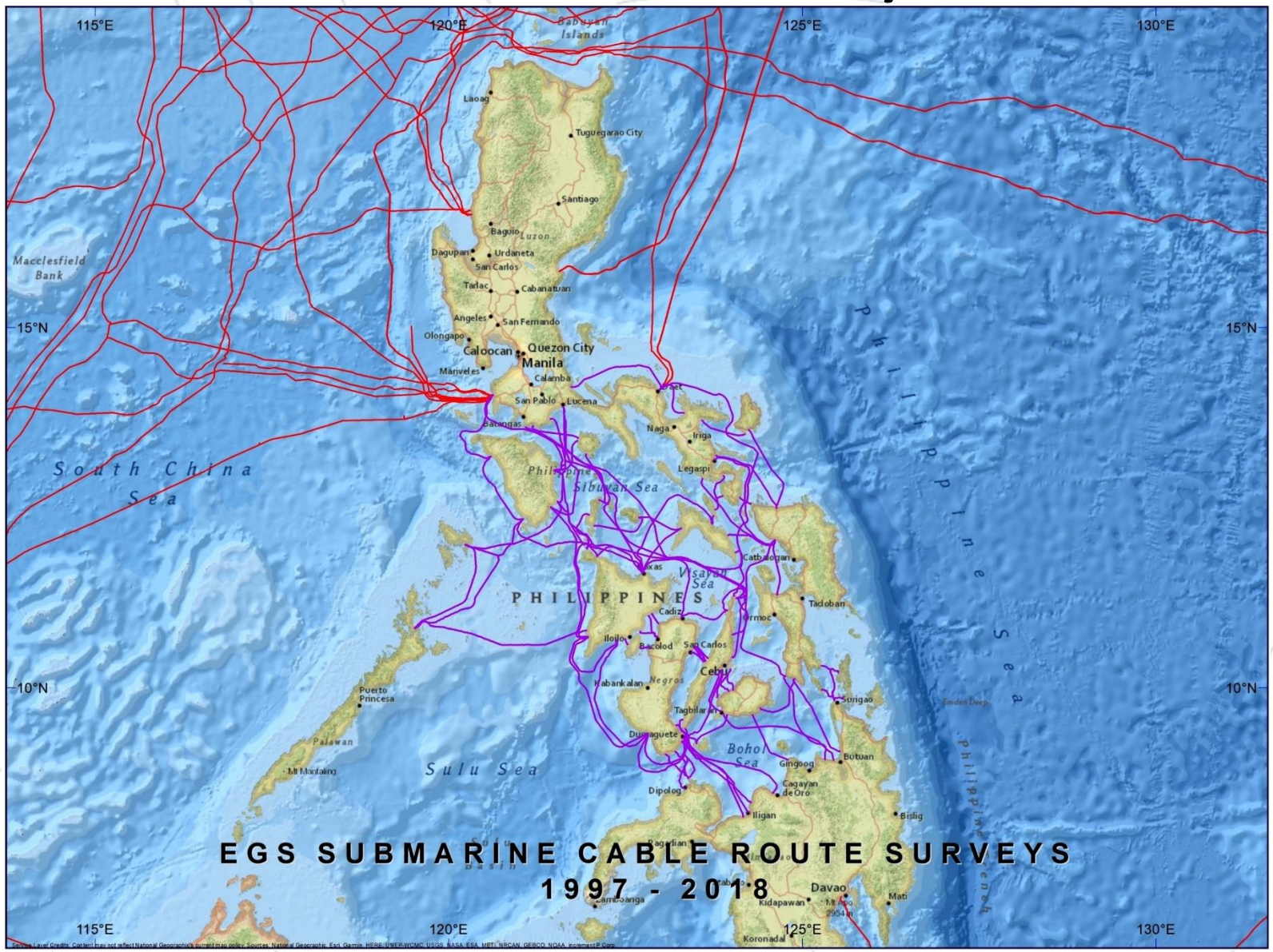
Inter-Island cable systems

Richard HALE
Director
EGS Survey Group
representing the
International Cable
Protection Committee

UN ICP on Oceans and the Law of the Sea

Underwater Sounds from Cable Operations

Slide 5



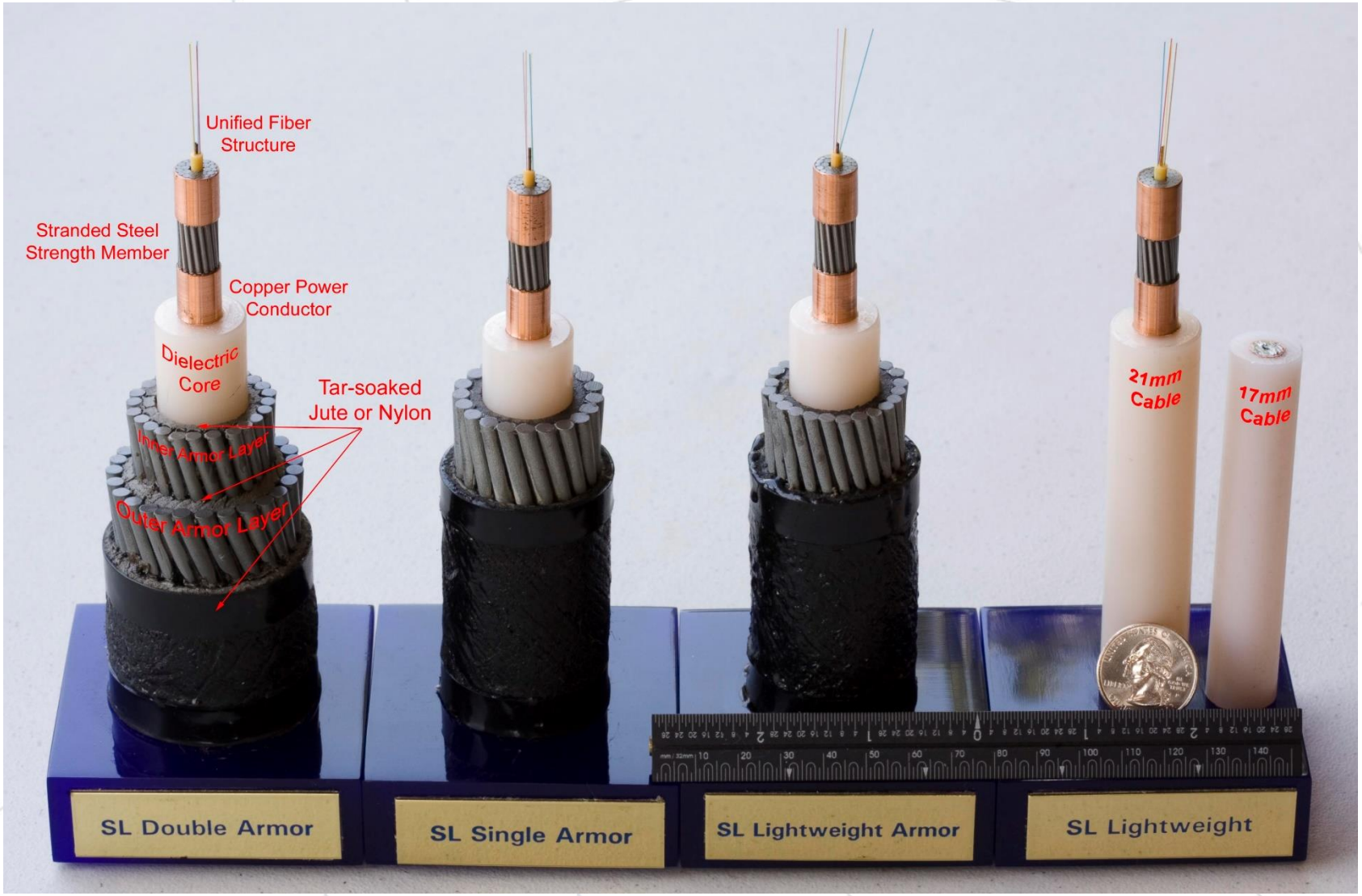
Submarine Fibre-Optic Cables

Richard HALE
Director
EGS Survey Group
representing the
International Cable
Protection Committee

UN ICP on Oceans and the Law of the Sea

Underwater Sounds from Cable Operations

Slide 6



Richard HALE
Director
EGS Survey Group
representing the
International Cable
Protection Committee

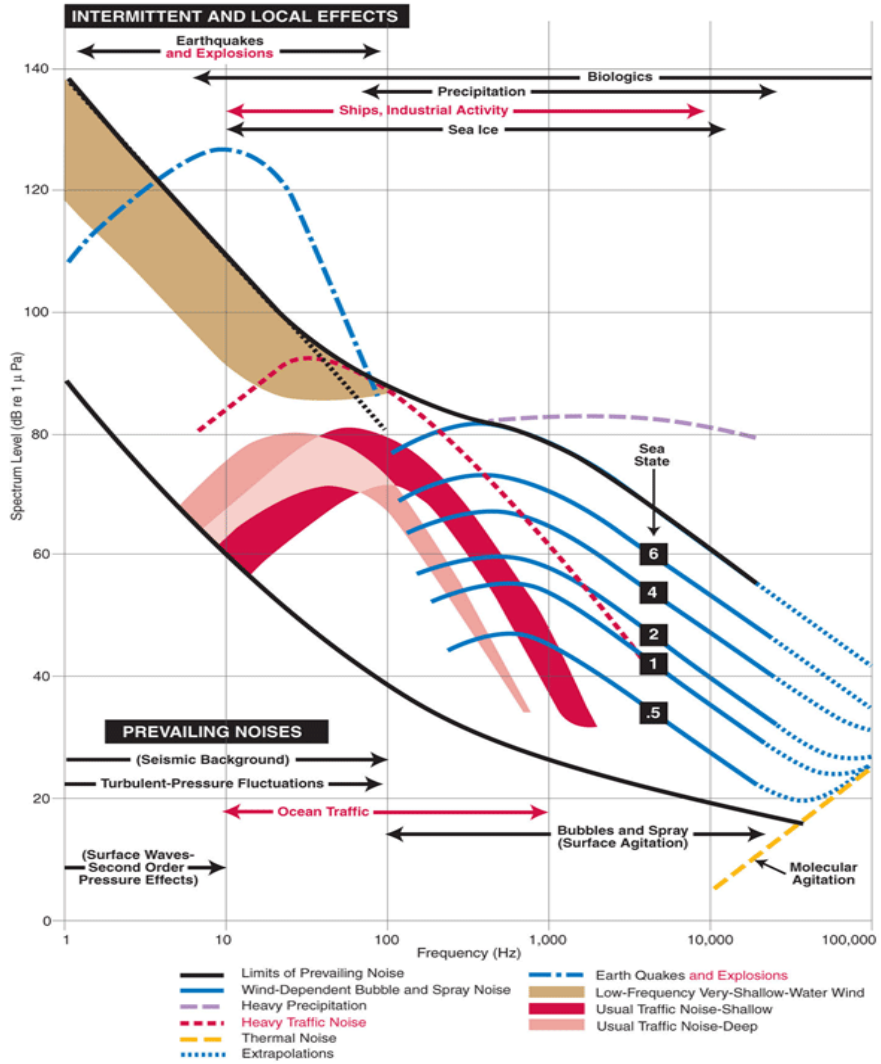
UN ICP on Oceans and the Law of the Sea

Underwater Sounds from Cable Operations

Slide 7

Sounds in the seas and oceans vary all the time

- Wind & Waves
- Rainfall
- Background seismic activity
- Wide range of biological sources, such as snapping shrimp, many fish species and cetaceans.
- Human sources, such as ships, hydrocarbon exploration and offshore construction



Wenz Diagram: https://dosits.org/science/sounds-in-the-sea/what-are-common-underwater-sounds/

Richard HALE
Director
EGS Survey Group
representing the
International Cable
Protection Committee

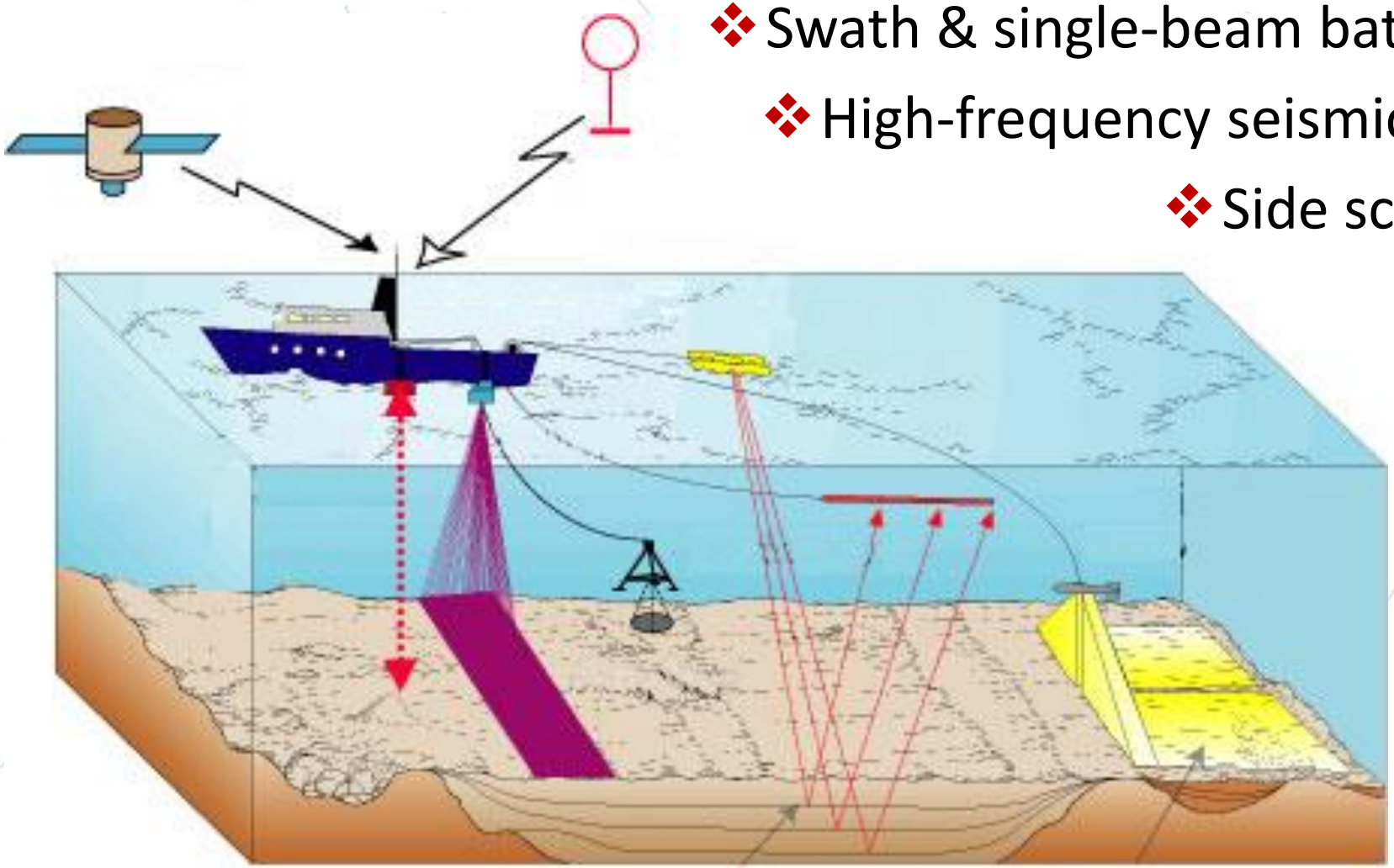
UN ICP on Oceans and the Law of the Sea

Underwater Sounds from Cable Operations

Slide 8

Sounds from Cable & Pipeline Surveys

- Swath & single-beam bathymetry
- High-frequency seismic profiler
- Side scan sonar



Source: Woods Hole Coastal & Marine Science Centre, USGS, https://woodshole.er.usgs.gov/operations/sfmapping/seafloor.htm

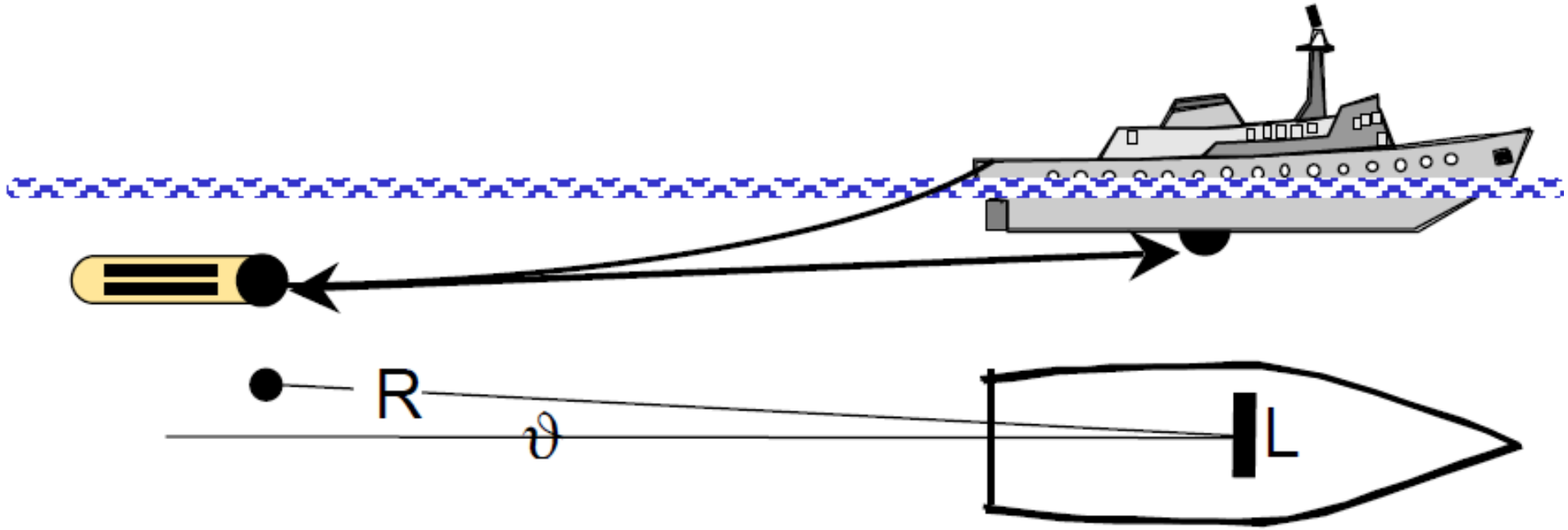
Richard HALE
Director
EGS Survey Group
representing the
International Cable
Protection Committee

UN ICP on Oceans and the Law of the Sea

Underwater Sounds from Cable Operations

Slide 9

Underwater Positioning - USBL



Source: Wells D., 2010, Positioning Models and Methods, OMG/CCOM Multibeam Sonar Course

Examples of Survey Vessels

Richard HALE
Director
EGS Survey Group
representing the
International Cable
Protection Committee

UN ICP on Oceans and the Law of the Sea

Underwater Sounds from Cable Operations

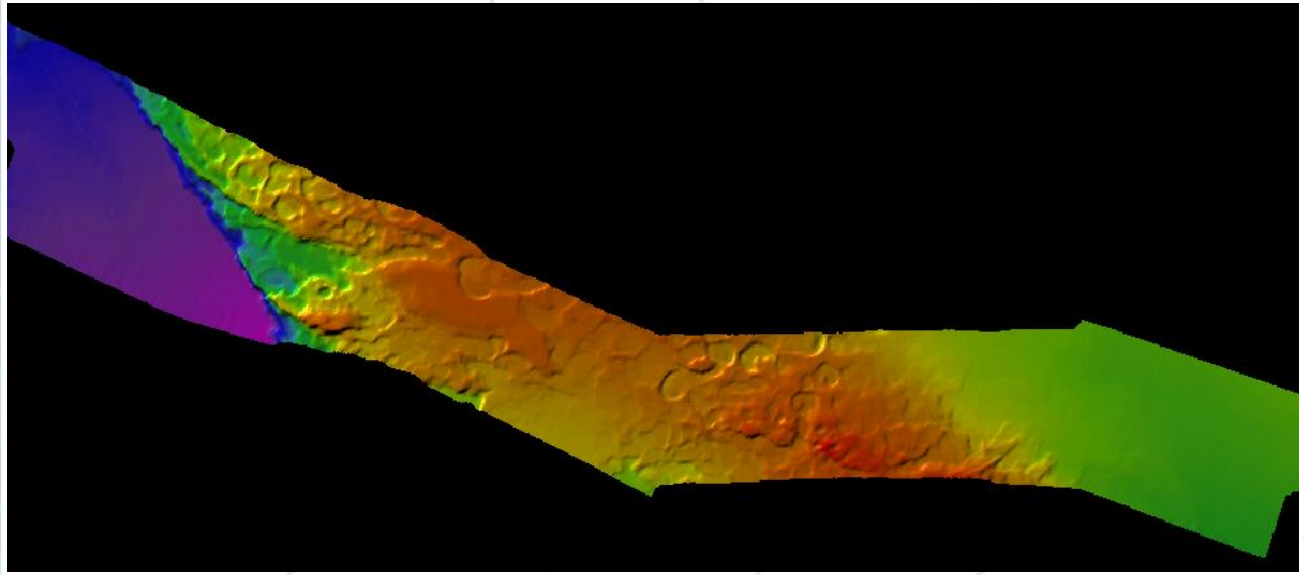
Source: EGS Library

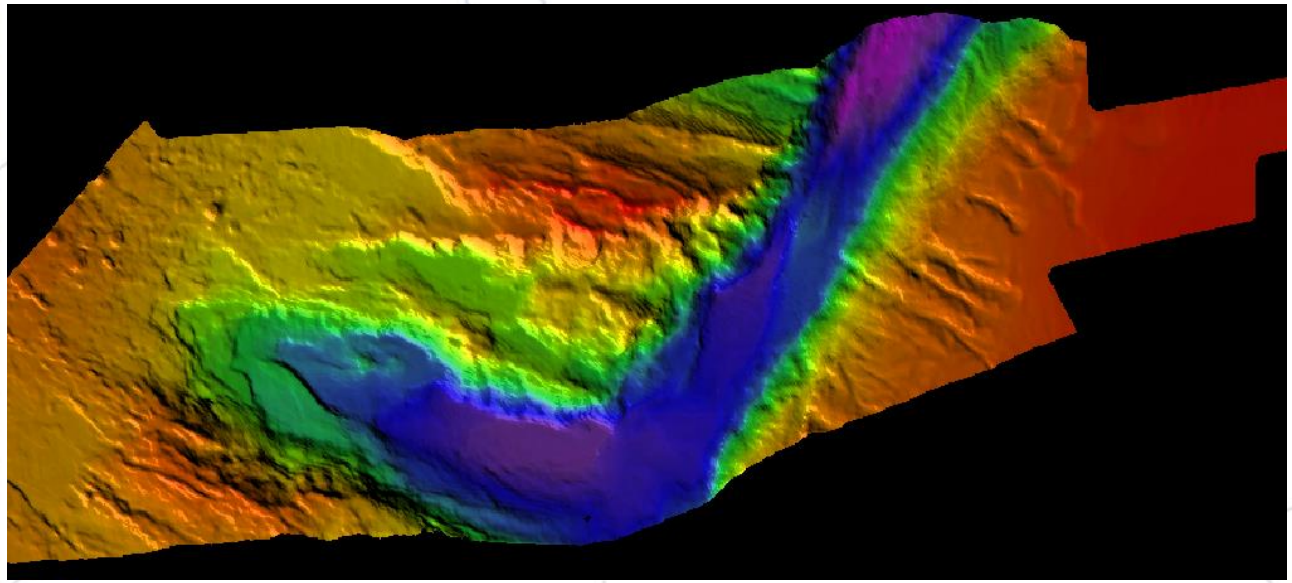
Sounds are introduced to map the seabed

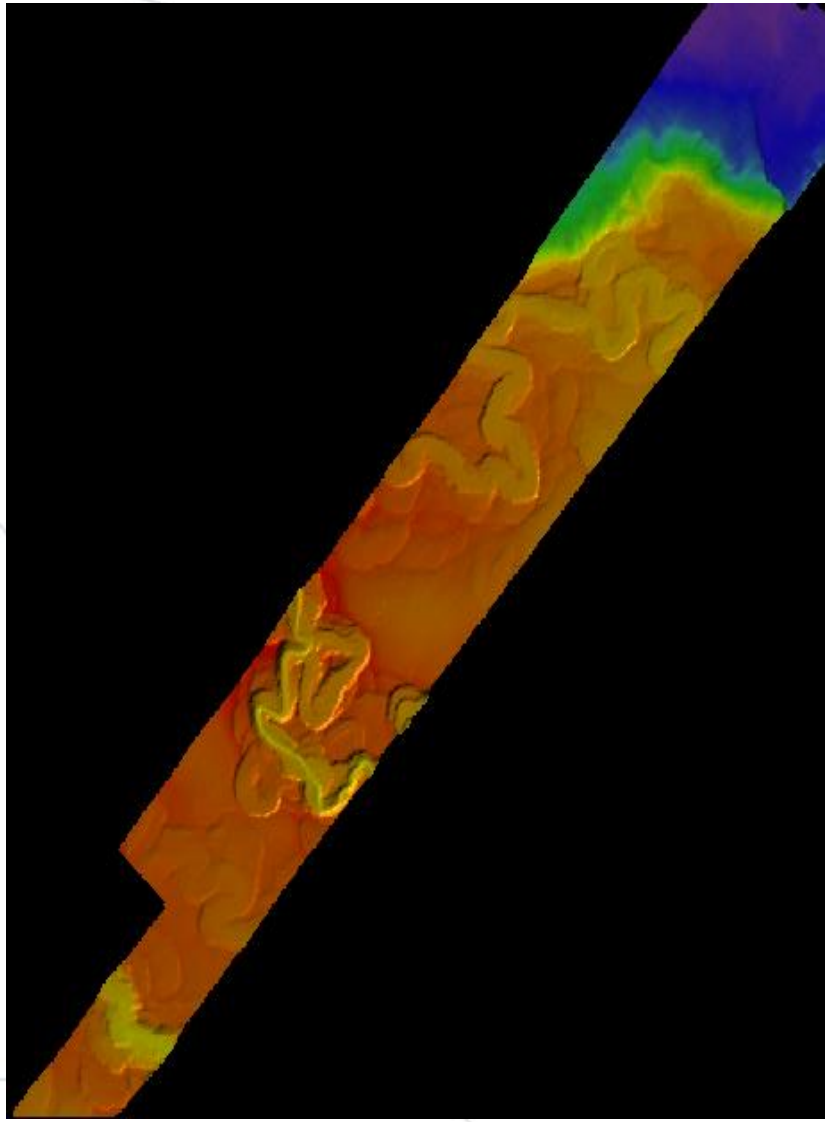
Richard HALE
Director
EGS Survey Group
representing the
International Cable
Protection Committee

UN ICP on Oceans and the Law of the Sea

Underwater Sounds from Cable Operations







Source: EGS Library

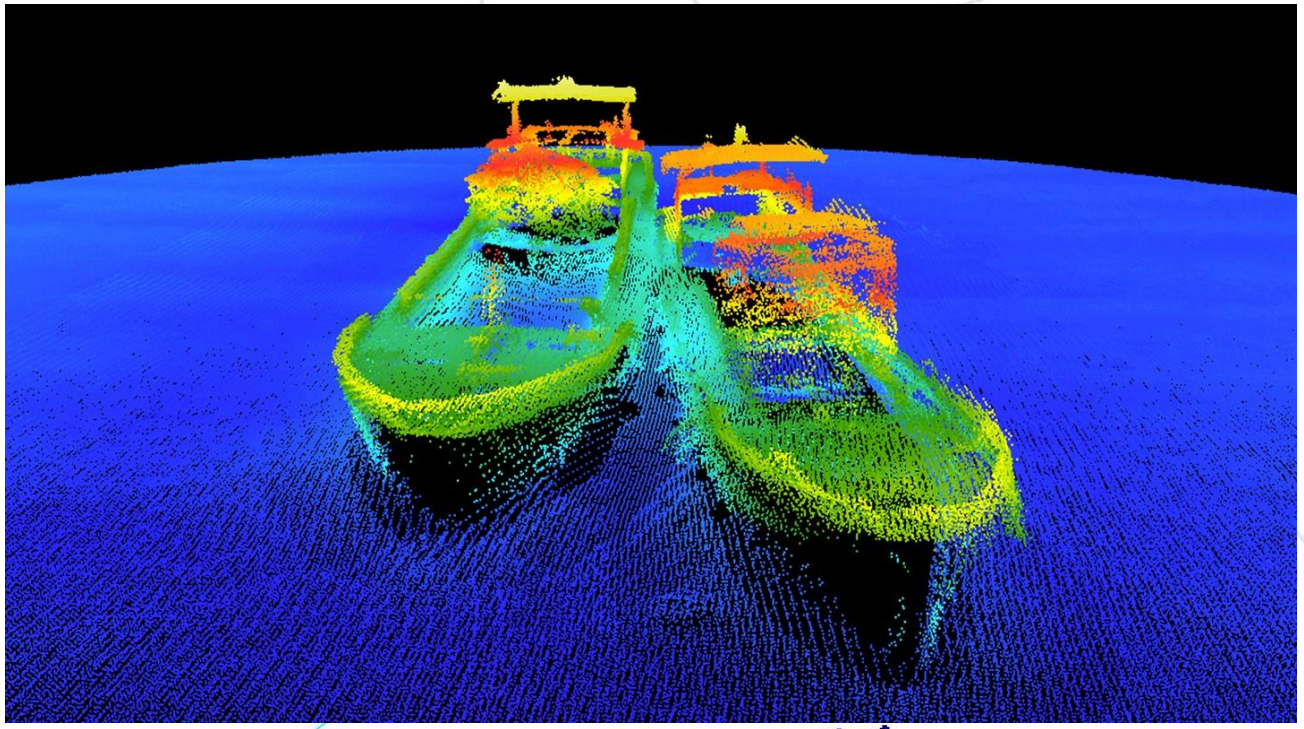
Sounds are introduced to map obstructions

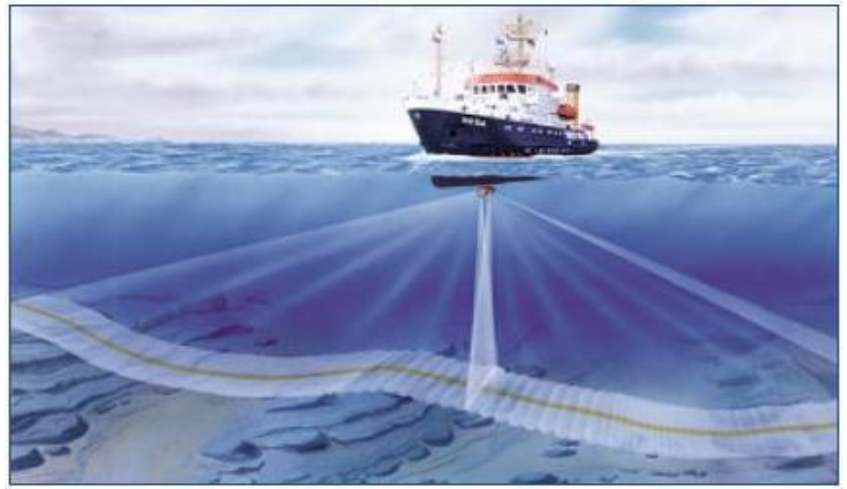
Richard HALE
Director
EGS Survey Group
representing the
International Cable
Protection Committee

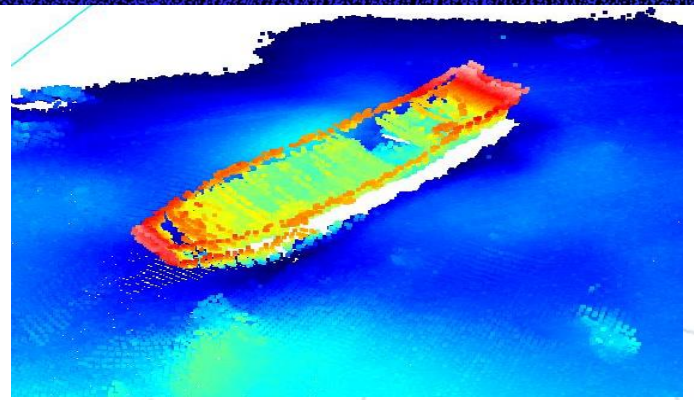
UN ICP on Oceans and the Law of the Sea

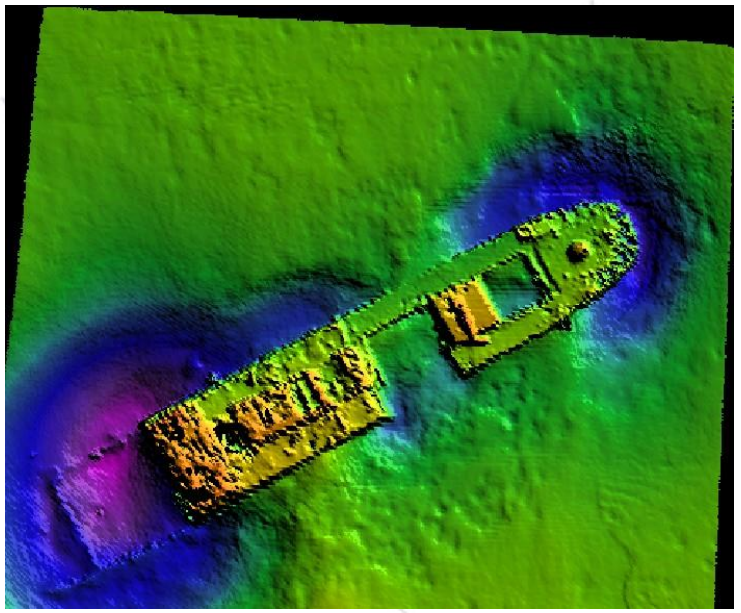
Underwater Sounds from Cable Operations

Slide 12









Sources: https://www.epd.gov.hk/eia/register/report/eiareport/eia_1252006/html/eiareport/Part3/Section12/sec3_12_Annex12b.htm and EGS Library

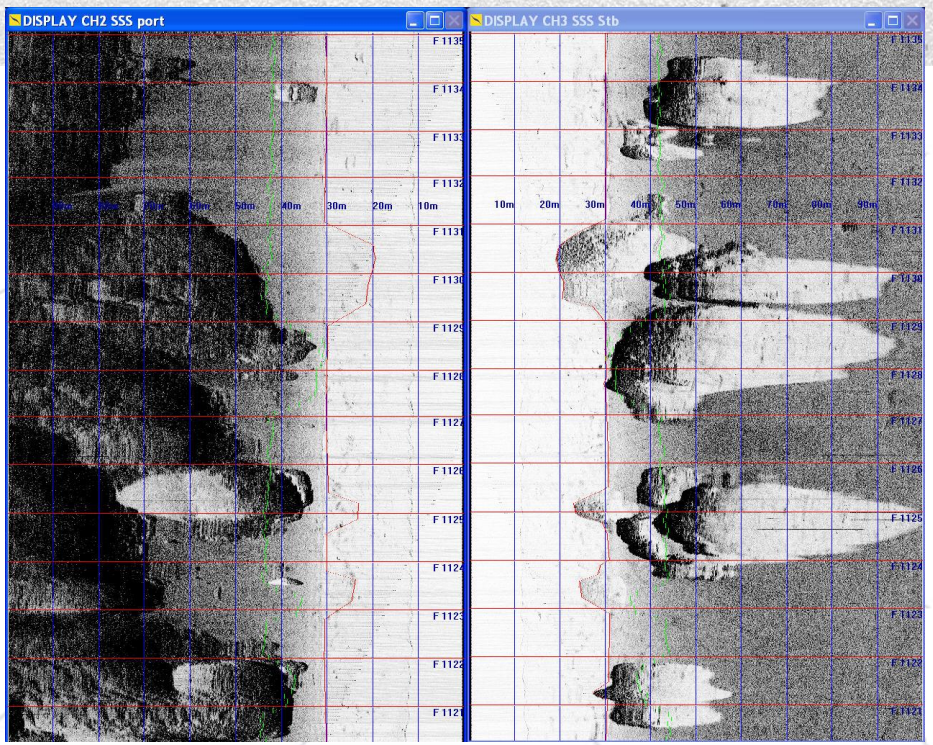
Sounds are introduced to map obstructions

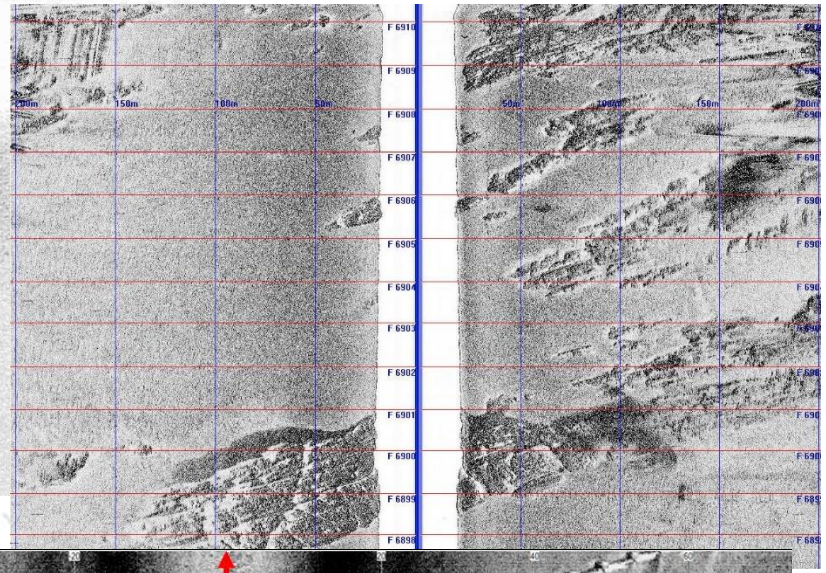
Richard HALE
Director
EGS Survey Group
representing the
International Cable
Protection Committee

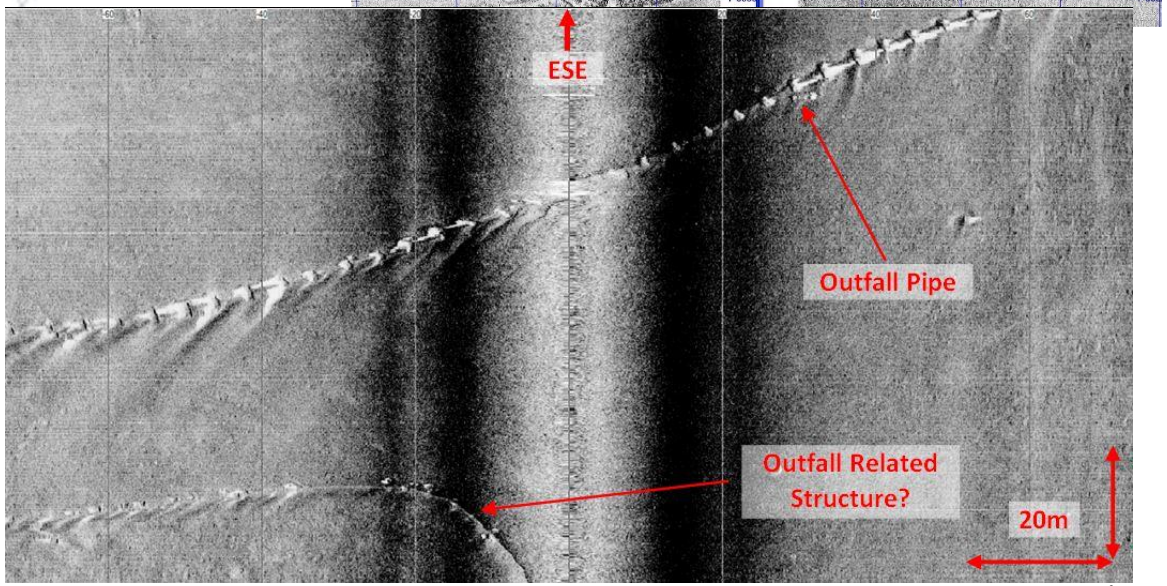
UN ICP on Oceans and the Law of the Sea

Underwater Sounds from Cable Operations

Slide 13







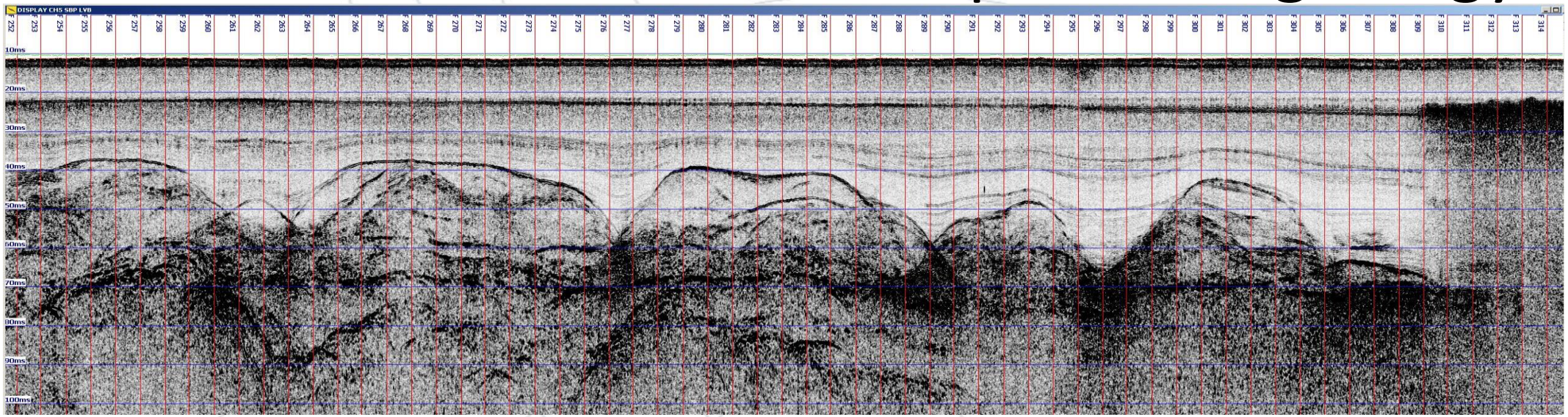
Sources: EGS Library

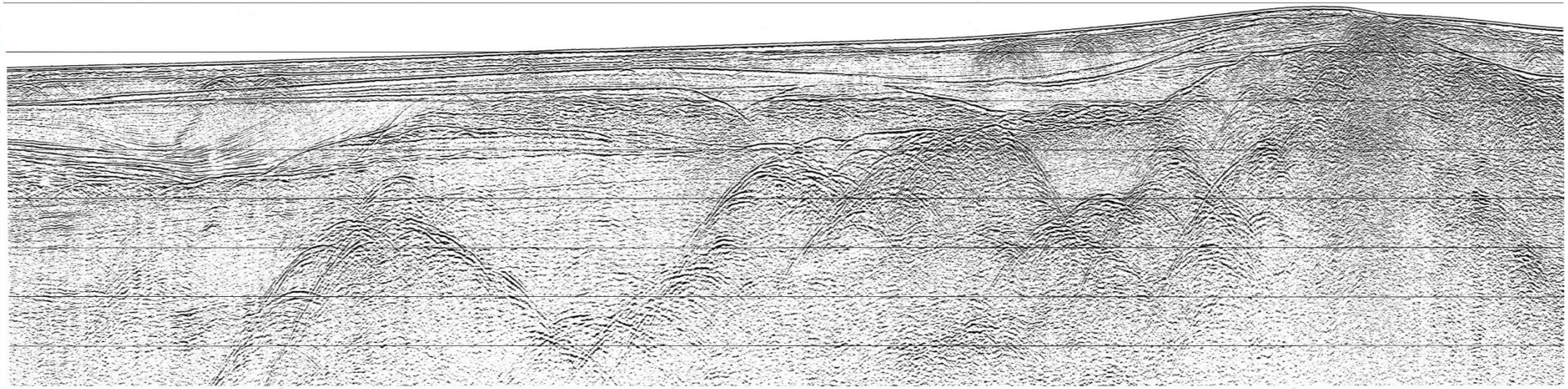
Sounds are introduced to map seabed geology

Richard HALE
Director
EGS Survey Group
representing the
International Cable
Protection Committee

UN ICP on Oceans and the Law of the Sea

Underwater Sounds from Cable Operations





Source: EGS Library

Richard HALE
Director
EGS Survey Group
representing the
International Cable
Protection Committee

UN ICP on Oceans and the Law of the Sea

Underwater Sounds from Cable Operations

Slide 15

Typical Sound Source Characteristics - 1

- Given seawater conditions, it is possible to calculate the sound level at different distances from a sound source.
- The following table assumes: water temperature 15°C; salinity 35 psu; frequency-dependent attenuation [5]; spherical divergence; ignore beam-forming and refraction; maximum instrument power settings.
- Many studies have defined the sound level of 180 dB re 1µPa as "harassment"; and 160 dB re 1µPa is the level likely to cause "behavioral response" (e.g. avoidance) [6]. Use these values as a starting point to estimate the size of the area affected by anthropogenic sounds.
- The assumptions are a simplification, intended to give an idea of scale; a starting point for assessing the *acoustic footprint*.

Typical Sound Source Characteristics - 2

Instrument	Operating Frequency (kHz)	Sound Source Level (dB re 1 µPa-m)	Distance (km) to 180 dB re 1 µPa-m	Distance (km) to 160 dB re 1 µPa-m
Side Scan Sonar	450	235	0.11	0.23
	100	235	0.22	0.54
Single Beam Echo Sounder	212	213	0.03	0.13
	38	213	0.04	0.32
Swath bathymetry	400	221	0.06	0.17
	70	228	0.08	0.42
	12	242	0.8	4.8
USBL	23	206	0.02	0.19
Low-Voltage Boomer	0.8	215	0.06	0.57
Oil exploration seismic (single airgun, 33 litres, 13.8 MPa) (7)	0.1	232	0.5	5.6
Pile-driving (8)	0.2	262	12	130

Richard HALE
Director
EGS Survey Group
representing the
International Cable
Protection Committee

UN ICP on Oceans and the Law of the Sea

Underwater Sounds from Cable Operations

Richard HALE
Director
EGS Survey Group
representing the
International Cable
Protection Committee

UN ICP on Oceans and the Law of the Sea

Underwater Sounds from Cable Operations

Slide 17

Different Types of Seismic Surveys

Instrument	Operating Frequency (kHz)	Sound Source Level (dB re 1 µPa-m)	Distance (km) to 180 dB re 1 µPa-m	Distance (km) to 160 dB re 1 µPa-m
Chirp pinger	10	202	0.01	0.1
Pinger	7	207	0.03	0.3
4x4 Pinger Array	3.5	225	0.17	1.5
Low-Voltage Boomer	0.8	215	0.06	0.6
Sparker	0.5	215	0.06	0.6
Single Airgun (7)	0.1	232	0.6	5.6
Airgun Array (7)	0.1	252	4.3	43

- The values were calculated using simplifying assumptions, to allow a comparison. To avoid the assumptions, a site- and instrument-specific assessment should be considered for each project.
- They are both called “seismic surveys”, but seismic instruments for cable and pipeline surveys have a much smaller acoustic footprint than exploration seismic surveys.

Richard HALE
Director
EGS Survey Group
representing the
International Cable
Protection Committee

UN ICP on Oceans and the Law of the Sea

Underwater Sounds from Cable Operations

Slide 18

Underwater Sounds from Surveys

- Compared with other offshore activities, the lower-frequency acoustic instruments used during submarine cable and pipeline operations are directional and/or low energy.
- The higher-frequency instruments (above the hearing range of most animals) are all directional and sounds naturally attenuate over modest distances. Animals that can hear these sounds (particularly *Odontoceti*) have highly directional hearing.
- The surveys progress at ~3 km of route per day in shallow coastal waters, increasing to ~100 km/day across oceans. Usually, the area inside the acoustic footprint will not be re-surveyed for decades, when another cable is installed.
- The following slides show marine animals that have approached close to EGS survey vessels using a variety of these instruments.

Richard HALE
Director
EGS Survey Group
representing the
International Cable
Protection Committee

UN ICP on Oceans and the Law of the Sea

Underwater Sounds from Cable Operations

Slide 19

Dolphins around the bows of a ship while it was operating a 12 kHz swath bathymetry system

Richard HALE
Director
EGS Survey Group
representing the
International Cable
Protection Committee

UN ICP on Oceans and the Law of the Sea

Underwater Sounds from Cable Operations

Slide 20

Humpback whale apparently investigating a 1 kHz low-voltage Boomer

Richard HALE
Director
EGS Survey Group
representing the
International Cable
Protection Committee

UN ICP on Oceans and the Law of the Sea

Underwater Sounds from Cable Operations

Slide 21

Dugong near vessel operating 210 kHz single beam echo sounder, 100/450 kHz side scan and a 1 kHz low-voltage Boomer.

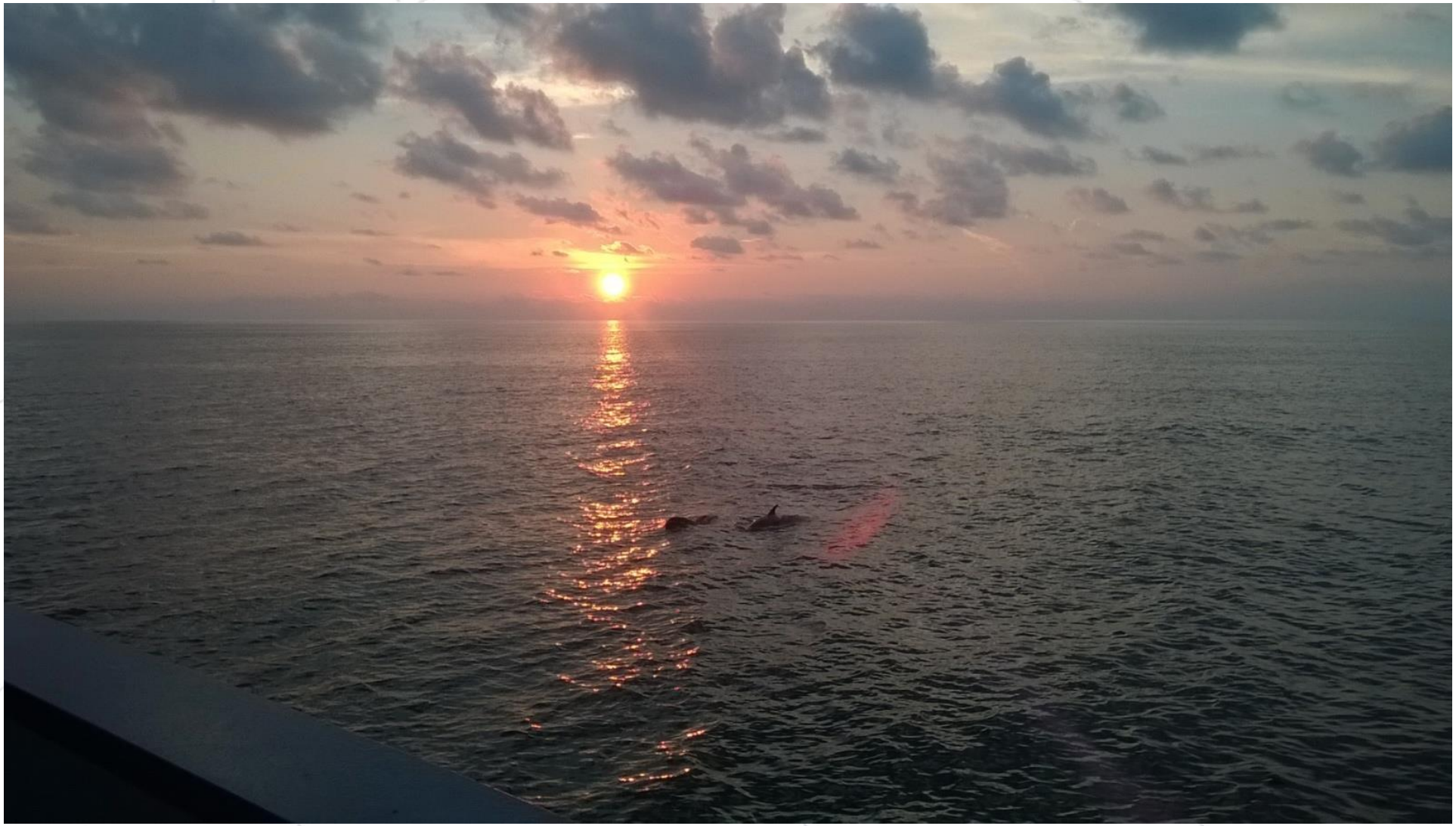
Richard HALE
Director
EGS Survey Group
representing the
International Cable
Protection Committee

UN ICP on Oceans and the Law of the Sea

Underwater Sounds from Cable Operations

Slide 22

Dolphins approaching vessel operating 100/450 kHz side scan, 200 kHz swath bathymetry, 25 kHz USBL and 2 kHz chirp pinger.



Sounds Generated During Cable Installation

Richard HALE
Director
EGS Survey Group
representing the
International Cable
Protection Committee

UN ICP on Oceans and the Law of the Sea

Underwater Sounds from Cable Operations

Slide 23

Diagram courtesy of TE Subcom, all rights reserved

Sounds Generated During Cable Installation

Richard HALE
Director
EGS Survey Group
representing the
International Cable
Protection Committee

UN ICP on Oceans and the Law of the Sea

Underwater Sounds from Cable Operations

Source: https://www.pinterest.com/pin/490751690620168584

Cable Burial from an Installation Barge - 1

Richard HALE
Director
EGS Survey Group
representing the
International Cable
Protection Committee

UN ICP on Oceans and the Law of the Sea

Underwater Sounds from Cable Operations

Cable Burial from an Installation Barge - 2

Richard HALE
Director
EGS Survey Group
representing the
International Cable
Protection Committee

UN ICP on Oceans and the Law of the Sea

Underwater Sounds from Cable Operations

Richard HALE
Director
EGS Survey Group
representing the
International Cable
Protection Committee

UN ICP on Oceans and the Law of the Sea

Underwater Sounds from Cable Operations

Slide 27

Sounds from Ships

- Installation vessels (ships and barges) are more powerful than survey vessels. Installation and survey vessels move slowly, typically 1 to 6 knots (~½ to 3 m/s).
- Sound source levels for these and comparable kinds of vessels are typically 155 to 170 dB re 1µPa m [7].
- For comparison, large commercial ships (tankers, bulk carriers, container ships) at their normal working speed generate sound levels ~180 dB re 1µPa m [7].

Richard HALE
Director
EGS Survey Group
representing the
International Cable
Protection Committee

UN ICP on Oceans and the Law of the Sea

Underwater Sounds from Cable Operations

Slide 28

Sound from Installation Operations

- A published value for cable trenching operations [8] gave a sound source level of 178 dB re 1µPa m.
- Unpublished information for cable jetting operations indicate a comparable sound source level, concentrated in the frequency range of 1 kHz to 15 kHz.
- The sounds of cable burial were attributed to cavitation bubbles as the water jets passed through the leading edge of the burial plough.
- Apart from the cable vessel itself, cables laid on the seabed (mostly water depths >1,000 m) do not generate any sound.

Richard HALE
Director
EGS Survey Group
representing the
International Cable
Protection Committee

UN ICP on Oceans and the Law of the Sea

Underwater Sounds from Cable Operations

Conclusions

- During survey and installation, ships move slowly: seldom >6 knots (~3 m/s), often less. Their engines and propellers generate little noise at such slow speeds compared with other ships.
- Sounds from instruments used for submarine cable and pipeline surveys naturally attenuate over modest distances. They have a small acoustic footprint.
- The footprint passes across any one area in a day (or sometimes a few days), then usually the area will not be affected again for decades.
- Cable burial operations involve water jets that have a low sound source level (178 dB re 1µPa m).
- After installation, cables are silent.
- The offshore community seeks regulations on anthropogenic sounds that are calibrated to the disturbance caused.

Richard HALE
Director
EGS Survey Group
representing the
International Cable
Protection Committee

UN ICP on Oceans and the Law of the Sea

Underwater Sounds from Cable Operations

Slide 30

References

Much of the information and images for this document have been sourced from the archives of the EGS Survey Group. Information from other sources have been given citation numbers in the text, with references below.

1. United Nations Secretary-General, 2015, Oceans and the Law of the Sea, UN Document A/70/74, 40p, http://www.un.org/depts/los/general_assembly/general_assembly_reports.htm.
2. Minges M., 2015, Exploring the Relationship Between Broadband and Economic Growth. The World Bank Development Report, 2016.
3. United Nations' Sustainable Development Goals, https://www.un.org/sustainabledevelopment/sustainable-development-goals/.
4. Burnett D. and Carter L., 2017, "International Submarine Cables and Biodiversity in Areas Beyond National Jurisdiction: The Cloud Beneath the Sea", Koninklijke Brill, Leiden, 72p.
5. Ainslie M. A. and McColm J. G., 1998, "A simplified formula for viscous and chemical absorption in sea water", Journal of the Acoustical Society of America, 103(3), 1671-1672.
6. Many studies, for example: National Marine Fisheries Service, 2016, Underwater Acoustic Thresholds for Onset of Permanent and Temporary Threshold Shifts, 189p.
7. Richardson W. J., Greene C. R., Malme C. I. and Thomson D. H., 1995, "Marine Mammals and Noise", Academic Press, San Diego, 576p.
8. Nedwell J., Langworthy J. and Howell D., 2003, "Assessment of Sub-Sea Acoustic Noise and Vibration from Offshore Wind Turbines and its Impact on Marine Wildlife", The Crown Estates Office Report 544 R 0424, 72p, www.subacoustech/information/downloads/reports/544R0424.pdf.