Noise and ocean renewables – listening for the deafening murmur

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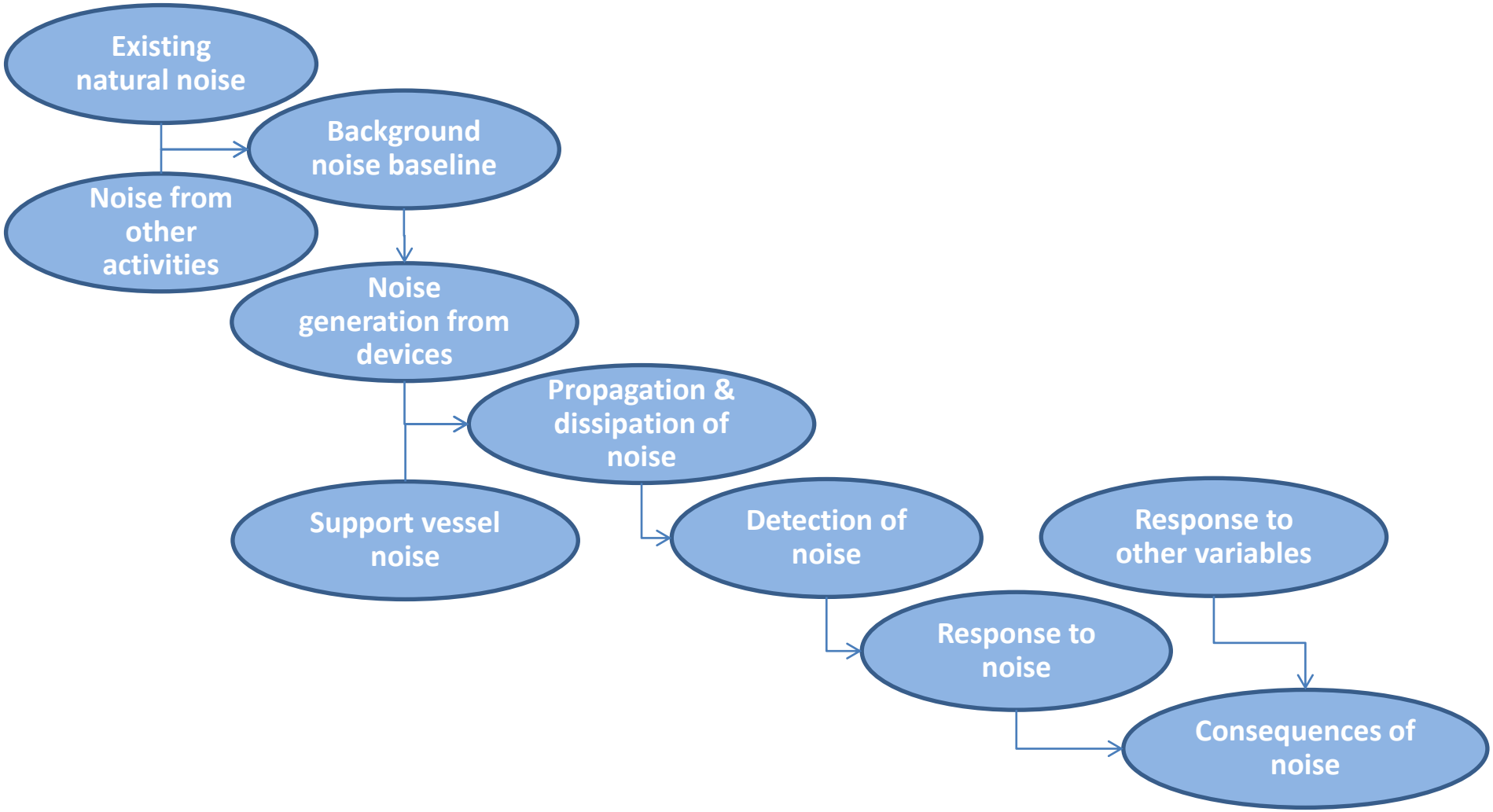
Overview

- The architecture of underwater noise issues
- Existing noise conditions in the sea
- Ocean energy devices coming through
- Comparison of different noise sources
- How should ocean energy projects be best managed

Architecture of underwater noise

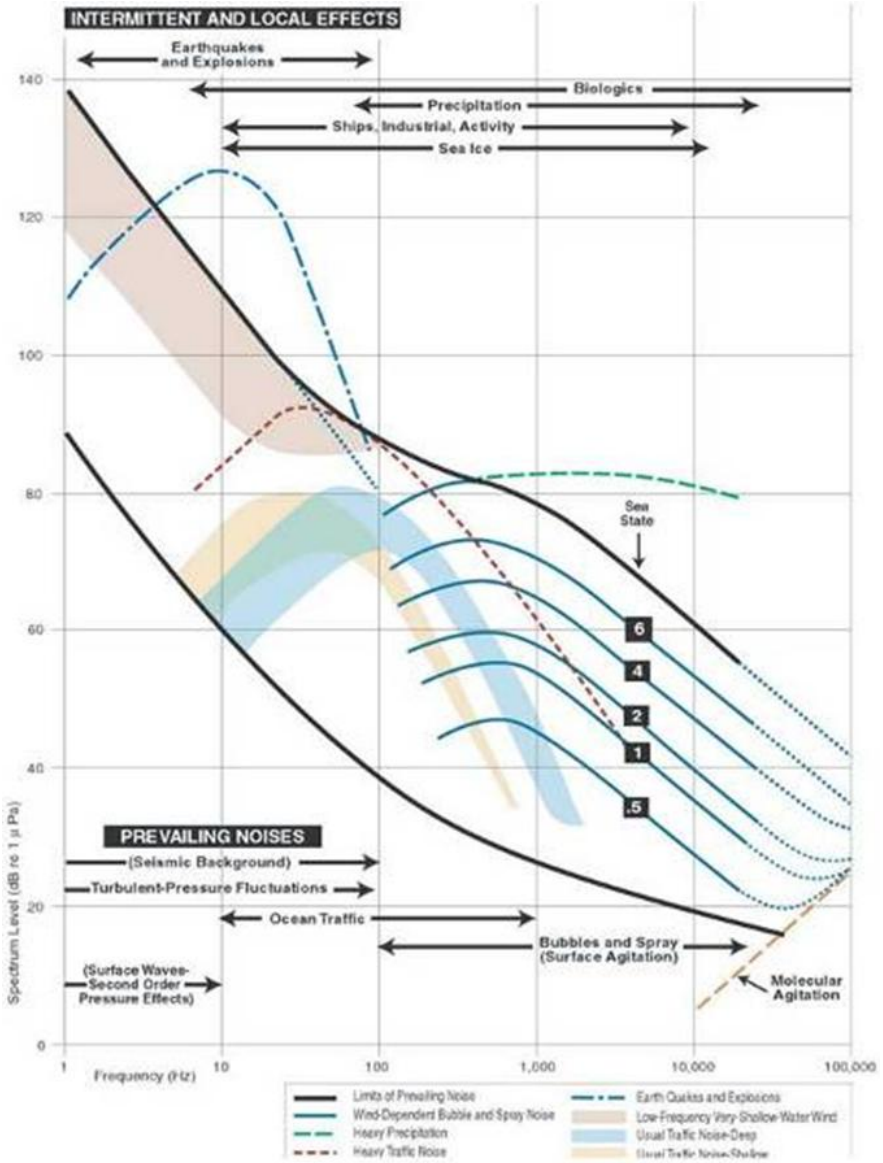


Existing sources	Locational background	Generation	Propagation	Detection	Response	Other trends	Consequences

Ambient noise levels

- Natural noise
  - Ocean waves
  - Coastal waves
  - Tidal currents
  - Earthquakes, eruptions
  - Fish, cetaceans, invertebrates
  - Precipitation

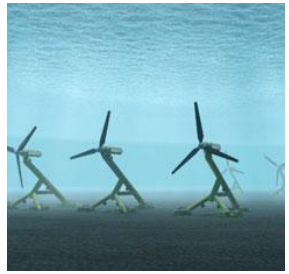
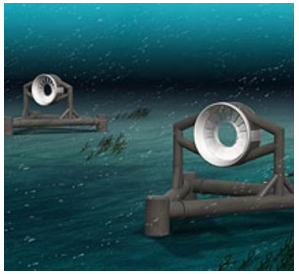
- Manmade noise
  - Merchant shipping
  - Offshore oil & gas
    - Seismic, drilling, production
  - Military activity
    - Shipping, weapons, acoustic tools
  - Recreational boating
  - Dredging
  - Fishing
  - Construction engineering
  - Ocean energy



Levels of activity around the world

- Number of ocean energy devices
  - 50
- Numbers of drilling rigs
  - 2,000
- Number of oil and gas platforms
  - 8,000
- Number of merchant ships
  - 100,000
- Number of fishing boats
  - 1.3 million mechanised boats
- Number of recreational boats
  - 12 million in US
  - 100 million? world wide

Power in the sea

	1 kw 1 hp	10 kw 10 hp	100 kw 100 hp	1,000 kw 1,000 hp	10,000 kw 10,000 hp	100,000 kw 100,000 hp
Boat engines				 		 
Wave devices						
Tidal devices						

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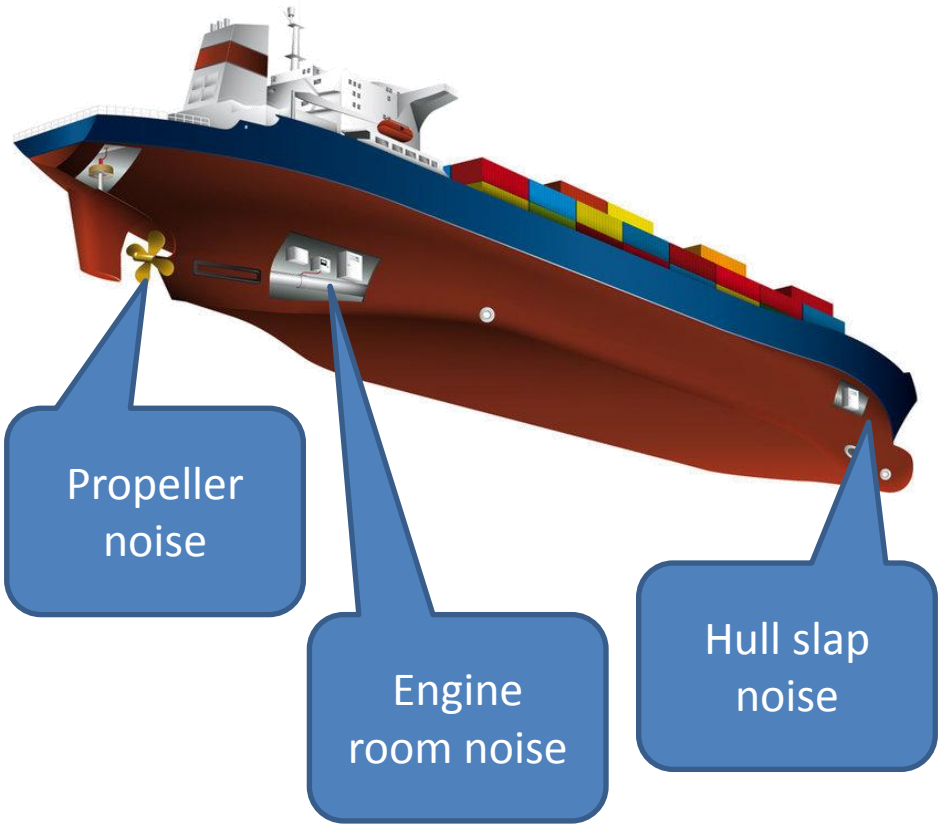
Merchant vessel noise

- Source levels
  - 100 dB to 180 dB
- Power outputs
  - 10 MW to 100 MW
- Noise
  - ~10% of energy
- Noise power
  - 100 kW to 10 MW



Support vessel noise

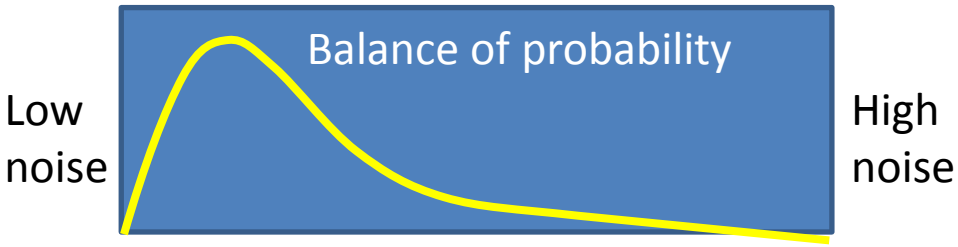
- Source levels
  - <80 dB
- Source power
  - 1MW to 10MW
- Noise
  - ~10%?
- Noise power
  - 100kW to 1MW

Ocean energy device noise

- Source levels
  - <80 dB
- Source power
  - 100 kW to 2 MW
- Noise
  - 0.01% to 0.5%
- Noise power
  - 10W to 10 kW

Near silent technologies?!

- Why do we assume noise is an issue?
- The levels of noise are as yet little known!
- Evidence suggests ocean energy machines can be very quiet!
- Balance of probability suggests noise levels will be low!



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Noise: EMEC vs FERRY vs SEA

All based upon 5 km areas

- EMEC
  - 6 MW generators
  - <5% mechanical loss
  - <0.5% transmitted into the sea
  - 30 kW
  - 8700 hrs x 40% = 3500hrs
  - 100,000 kWh
- Ferry
  - 8000 kW/8 MW engines
  - 80% transmitted into the sea
  - 6400 kW
  - 1 hr/day = 365 hrs
  - 2,300,000 kWh
- Sea
  - 20 kW/m over 5 km = 100 MW
  - 1% loss as noise at sea
  - 10% loss as noise at coast
  - 1-10 MW
  - 8700 hrs x 1000 = 8.700,000 kWh
  - 8700 hrs x 10000 = 87,000,000 kWh

0.1 GWh[noise]/yr (1)

2.3 GWh[noise]/yr (23)

(87 to 870)

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Research into noise

- Research can be undertaken at all stages
- Straight forward studies can take place around sources
- Determining effect & impact is a whole different ball game
- Just because we can dosen't mean we should in relation to research

Measure source levels of noise from different conditions and activities	Measure background noise levels over time and space	Measure source noise from devices, moorings, installation activities & support vessels	Measure and model the propagation of noise given local conditions	Establish hearing thresholds for different species	Describe and understand responses that species may make to noise stimuli, any adaptation over time and when other pressures may affect the response	Describe and understand other factors affecting individuals and populations leading to behavioural and distributional trends	Establish the consequences of changed behaviour and distribution upon the species and specific populations
Existing sources	Locational background	Generation	Propagation	Detection	Response	Other trends	Consequences

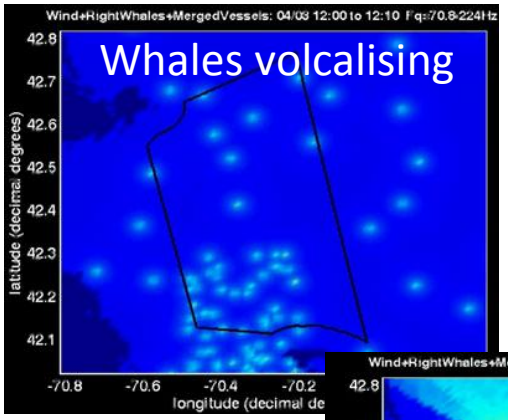
Managing noise

- There are measures that can be taken at each stage of activity
- Most effective interventions take place early in the process – associated with source
- Its more than a simple geographical co-location, but location is the biggest mitigation tool

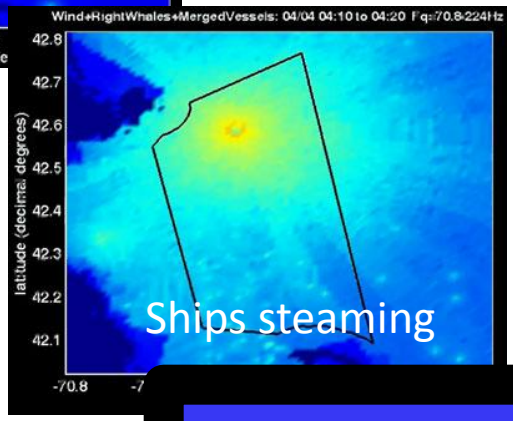
Reduce density or distribution of activities, minimise source levels	Choose sites with high levels of existing noise or away from other sources depending upon strategy	Avoid noise generation through design where needed, control support vessel activity. Choose frequencies which don't interfere with local species	Choose sites without exacerbating factors, use noise dampening measures if appropriate, move towards high frequencies	Choose sites away from specific noise sensitive species if necessary and possible	Avoid areas with specific sensitivities for vulnerable species, undertake operations at less sensitive times of year	Ensure wider trends and pressures on potentially vulnerable species are known and understood	Control operations when sensitive species are present
Existing sources	Locational background	Generation	Propagation	Detection	Response	Other trends	Consequences

Noise maps

- They need to reflect the variety of conditions that exist over space, time, conditions, frequencies as well as amplitudes
- Bigger issues than ocean energy to focus upon
- Need to consider whether to avoid or seek out noisy places during site selection



Top two diagrams from Cornell University research



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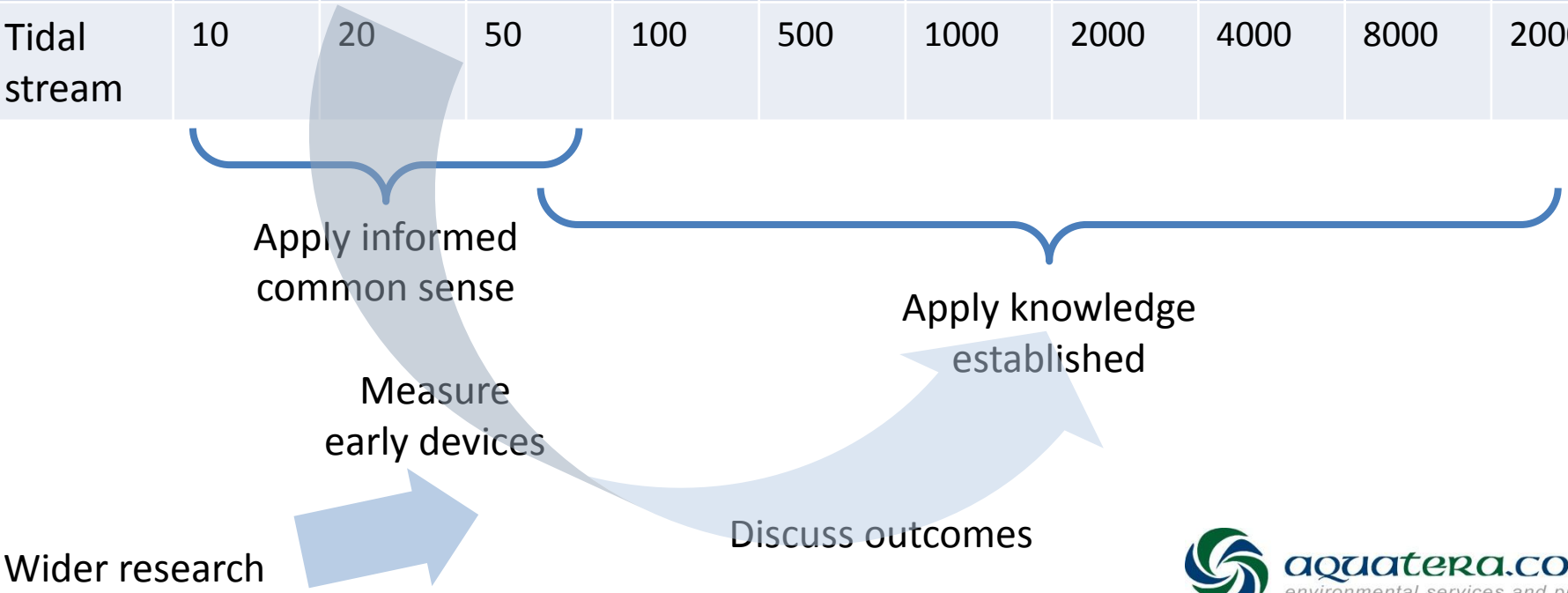
Build out rate for marine renewables

- We need to be aware of the low numbers of devices that will be deployed in the near term
- Space to deploy early devices and learn from their operation
- Even by 2020, full scale development will still be modest compared to other sea uses

Global MW?	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Wave	5	10	20	50	100	500	1000	2000	4000	8000
Tidal stream	10	20	50	100	500	1000	2000	4000	8000	20000



How to predict impacts

- Use established evidence
- Map out certainties and what we know!
- Catalogue uncertainties
- Consider where the balance of probability lies on all issues
- Investigate any areas of major concern (But tested against other monitoring priorities)

Key noise management issues

Actions to take

- Avoid noise if possible
- Reduce amplitude
- Increase (select) frequency
- Avoid key local species communication frequencies – if possible
- Avoid sensitive seasons for installation – if possible
- Avoid noise surprises, sudden changes

Note – nowhere does it say establish background noise levels, nor monitor noise outputs longer term!

Monitoring noise and deployment

- Strategic programmes should be in place and focussed on major noise sources – not ocean energy
- Technology developers should know the basic noise signature of their device
- All vessels should be treated with equal importance
- Experiences can be shared between jurisdictions but need to think about species present at any location

NOISE SHOULDN'T BE A SHOW STOPPER IN MOST PLACES FOR MOST PROJECTS

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Remember existing energy risks & impacts

Existing energy systems have led to, or are causing:

- Sea temperature rise
- Seawater acidification
- Polar ice melt
- Changing species distributions
- Increase in species extinctions
- Oil spills
- Oily water and chemicals discharges
- Radionuclide contamination
- Thermal pollution
- Water filtration
- Water abstraction
- Underwater noise
- Light pollution
- Flare mortality for birds
- Obstruction to shipping and fishing
- Seabed disturbance
- Seabed subsidence

The status quo is not without existing issues!!