Environmental Effects and Risk Retirement for Marine Renewable Energy

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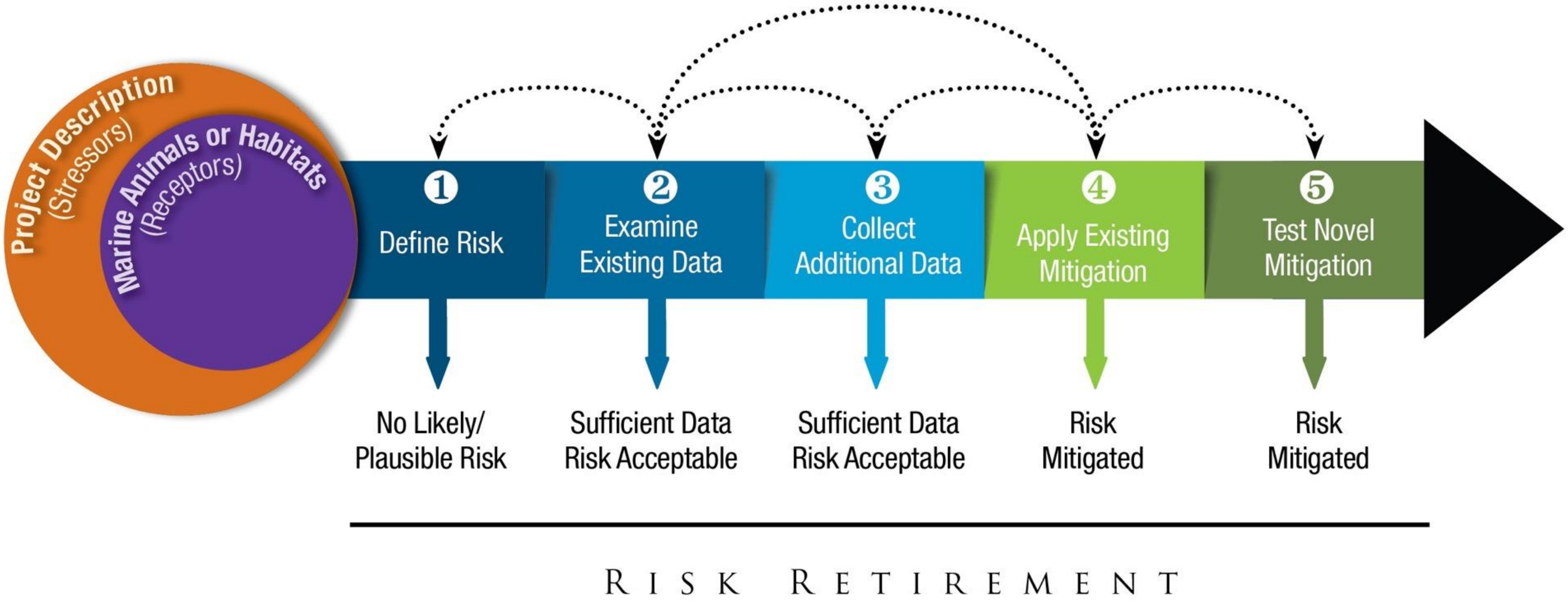
Ocean Energy ORJIP working to accelerate offshore consenting

Risk Retirement

- What is “risk retirement”?
  - For certain interactions, potential risks need not be fully investigated for every project for small developments (1-2 devices).
  - Rely on what is already known – already consented projects, research, or analogous industries.
  - A “retired risk” is not dead, and can be revived in the future as more information becomes available for larger arrays.

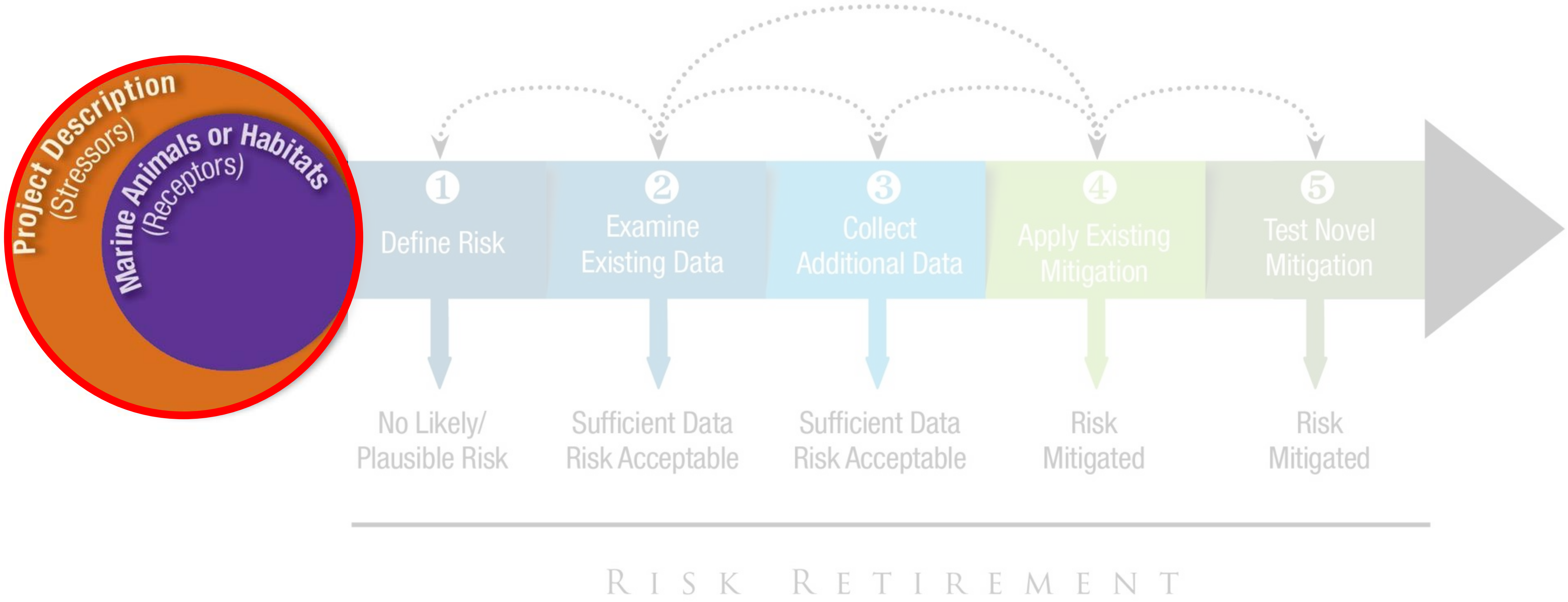
Pathway to Risk Retirement



Pathway to Risk Retirement

Define Interaction

- Project description (stressors)
- Marine animals or habitats (receptors)



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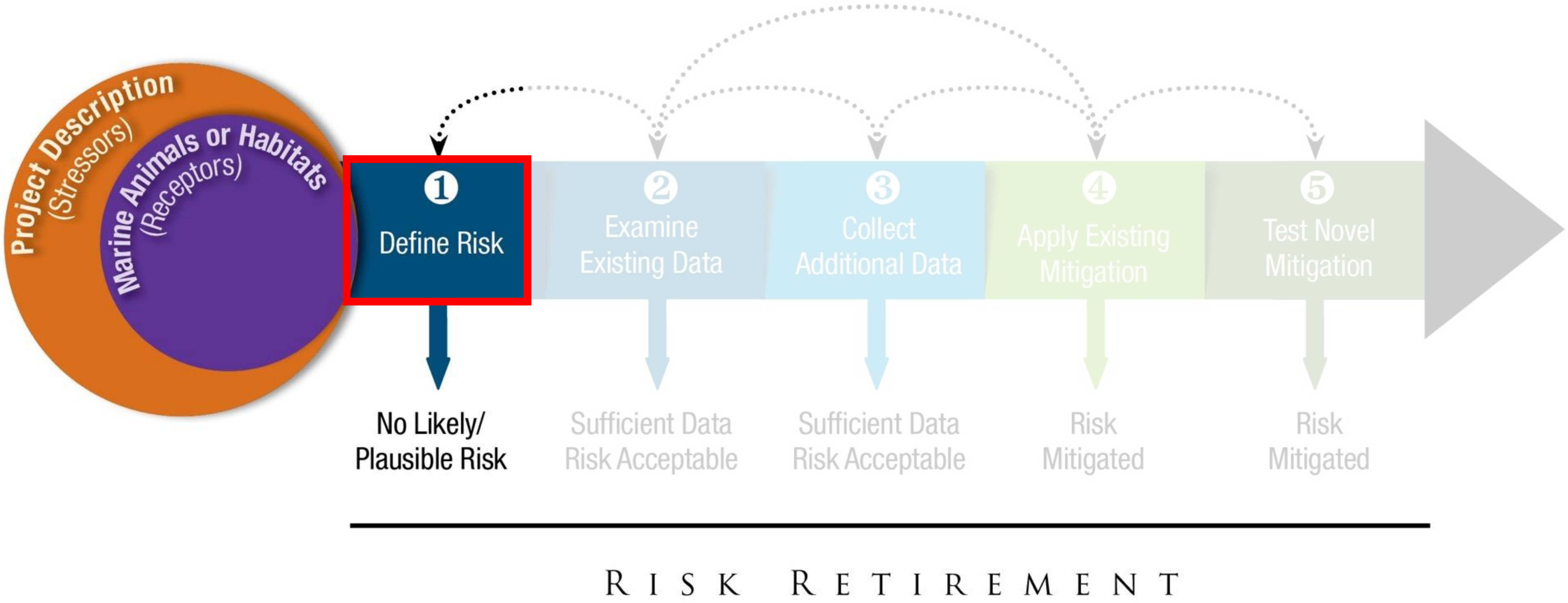
Pathway to Risk Retirement

Stage Gate 1

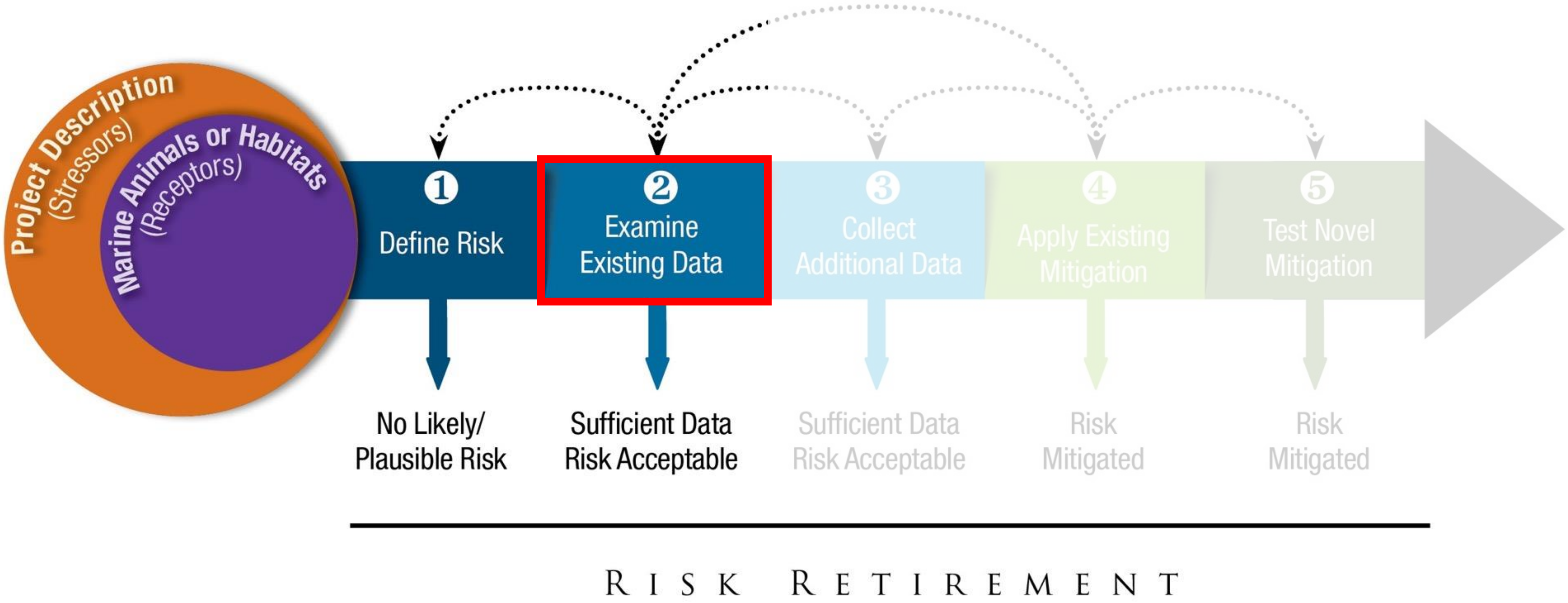
- Define if likely / plausible risk exists
  - If not, risk can be retired



Pathway to Risk Retirement

Stage Gate 2

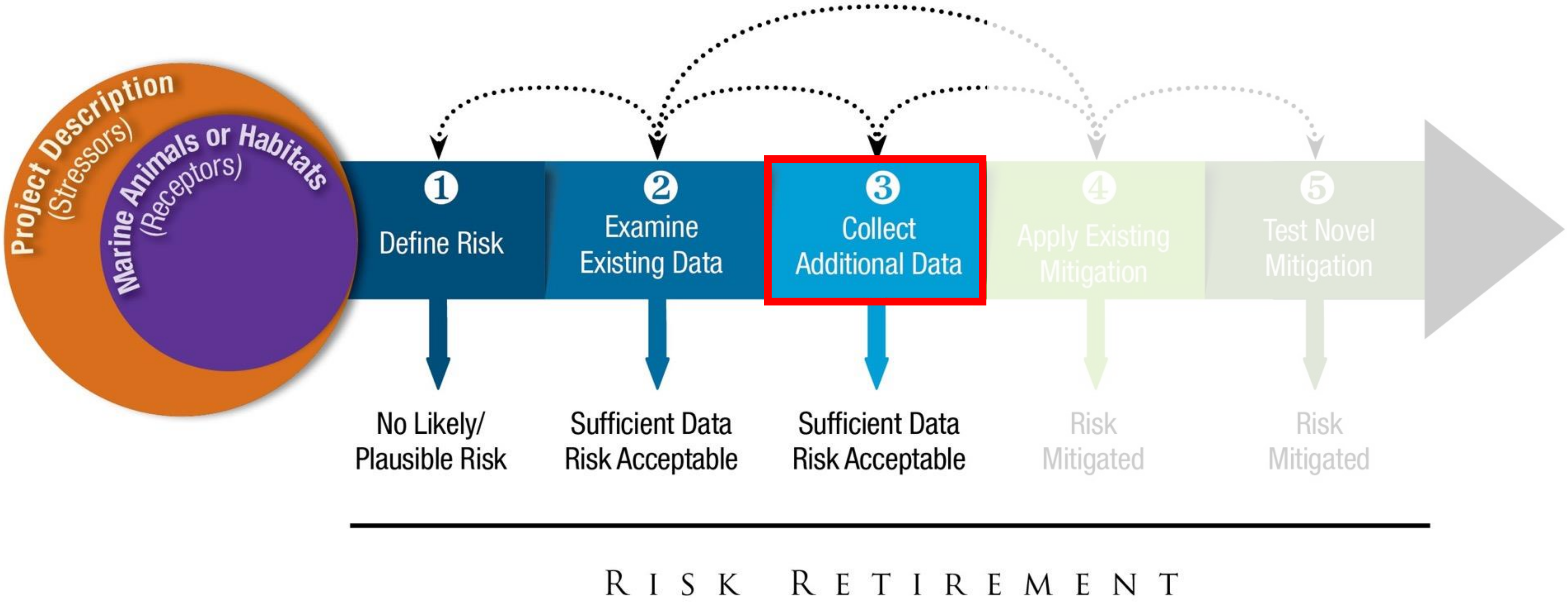
- Determine if sufficient data exists to demonstrate risk is acceptable
  - If so, risk can be retired



Pathway to Risk Retirement

Stage Gate 3

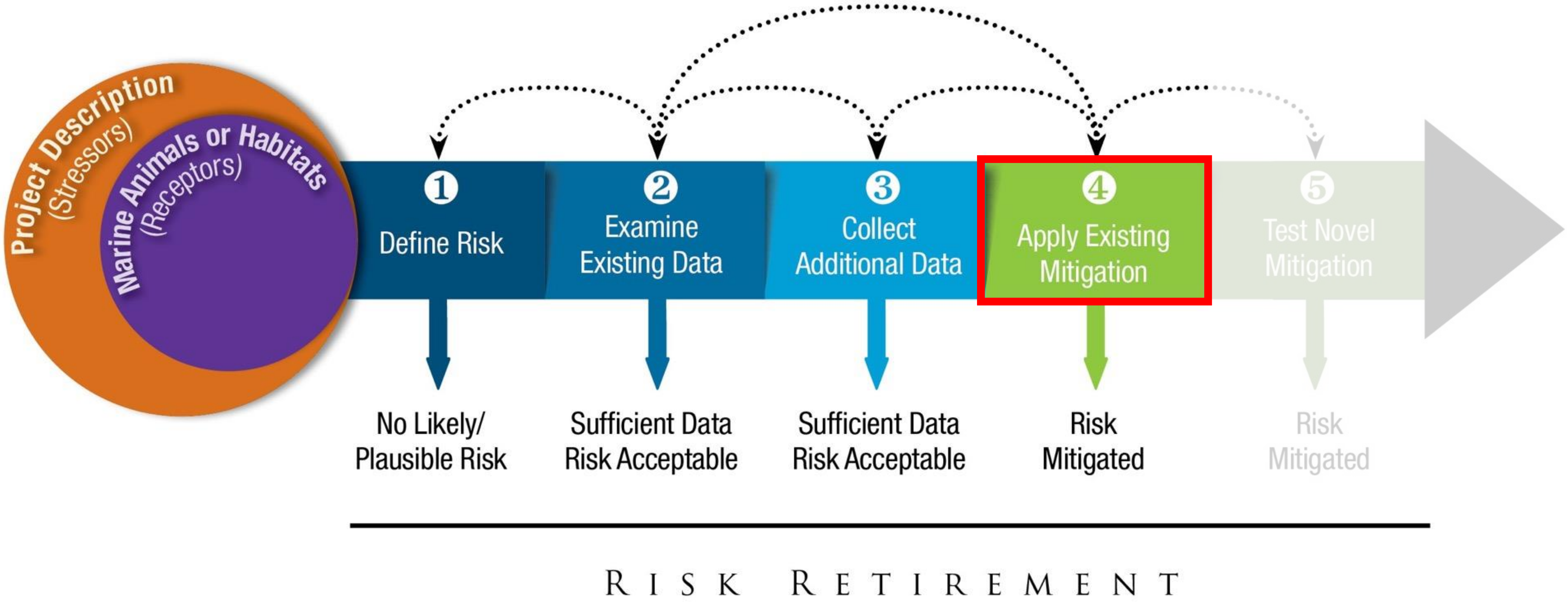
- Design studies and collect targeted project data
- Determine if risk is acceptable
  - If so, risk can be retired



Pathway to Risk Retirement

Stage Gate 4

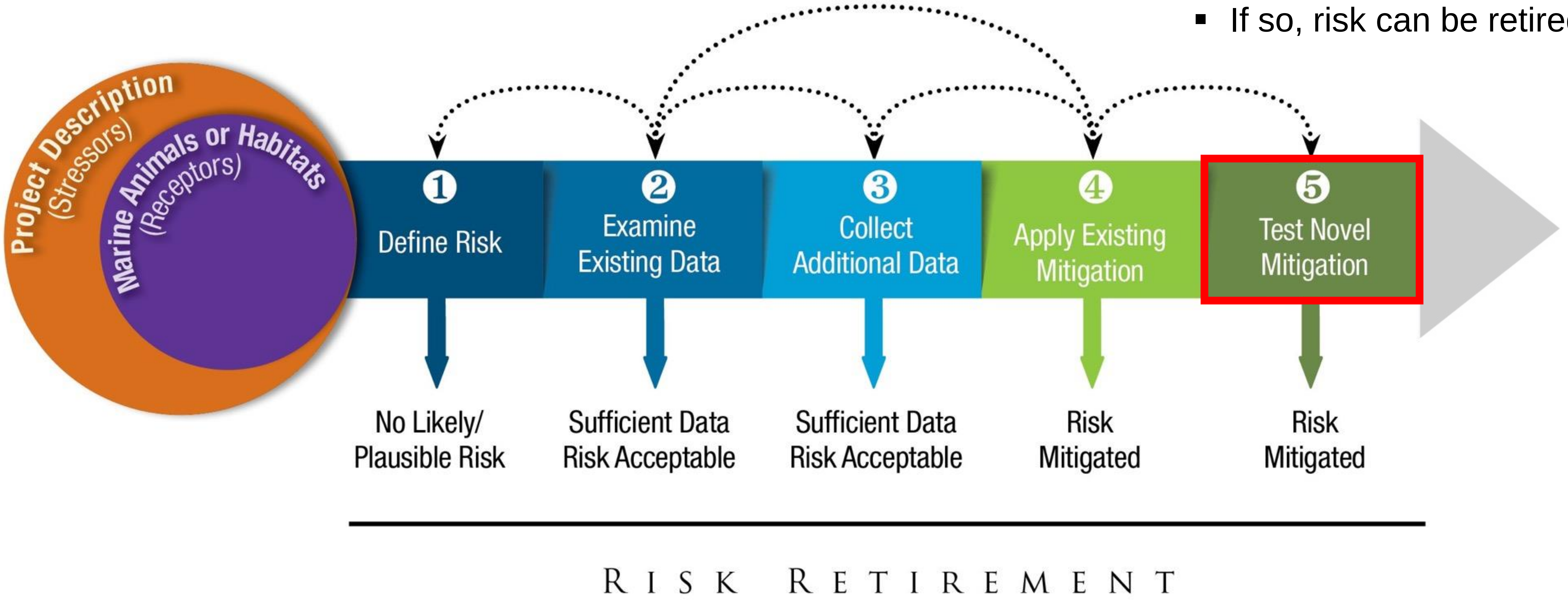
- Determine if proven mitigation measures are applicable to mitigate risk
  - If so, risk can be retired



Pathway to Risk Retirement

Stage Gate 5

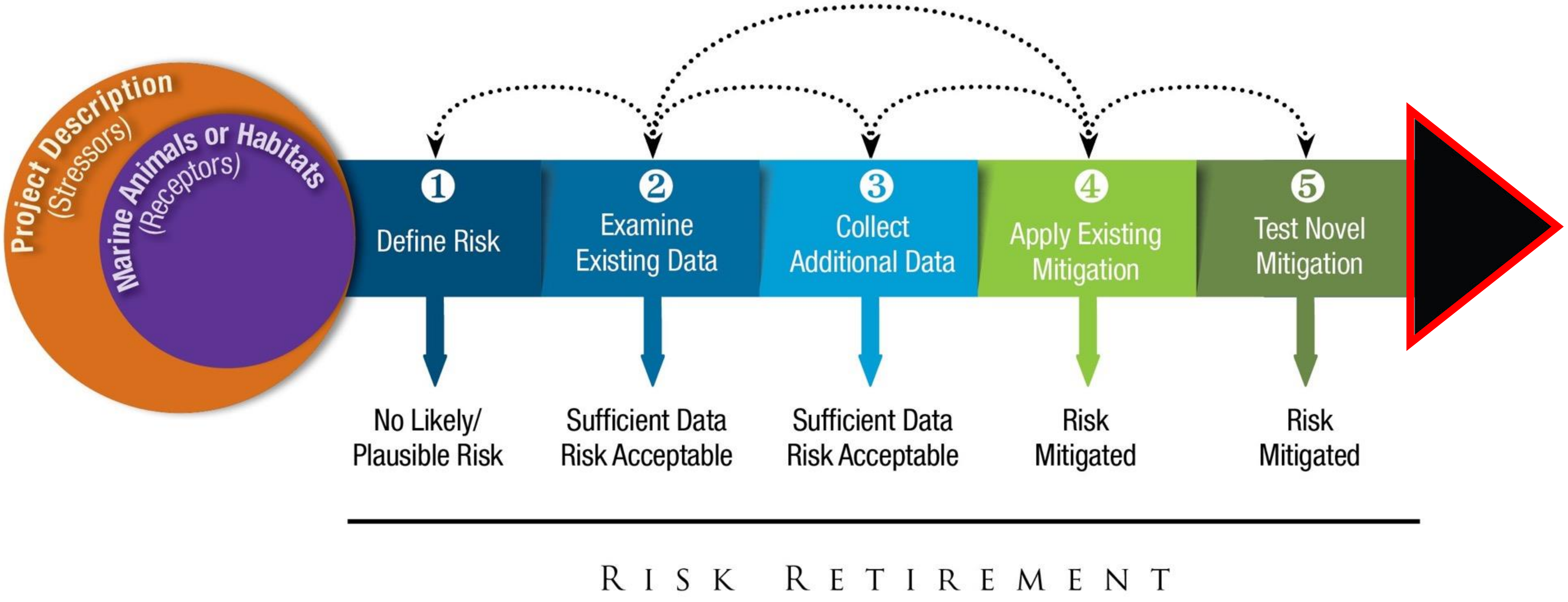
- Develop and test novel mitigation measures
- Determine if the risk can be mitigated
  - If so, risk can be retired



Pathway to Risk Retirement

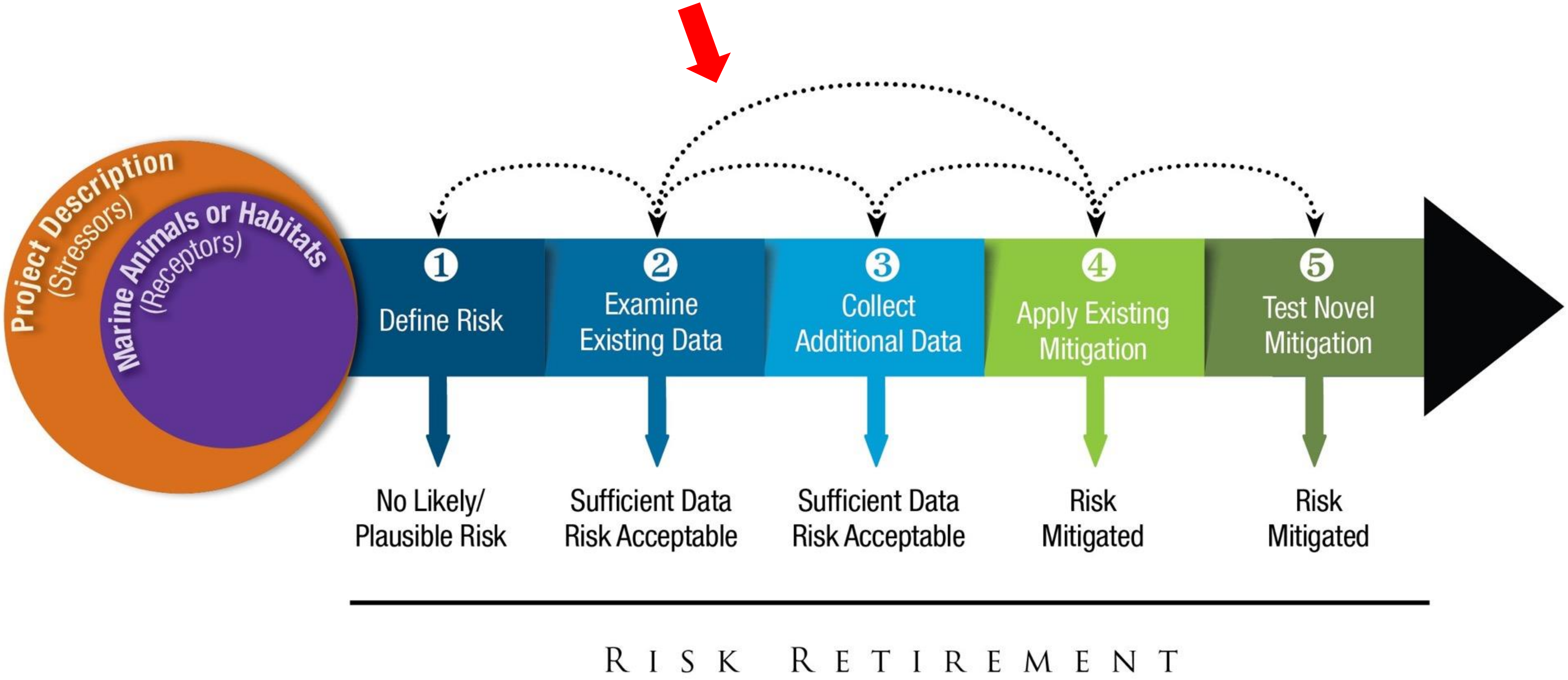
End of Pathway

- If risk is likely / plausible and cannot be mitigated
  - Need to redesign or possibly abandon project



Data Transferability Process

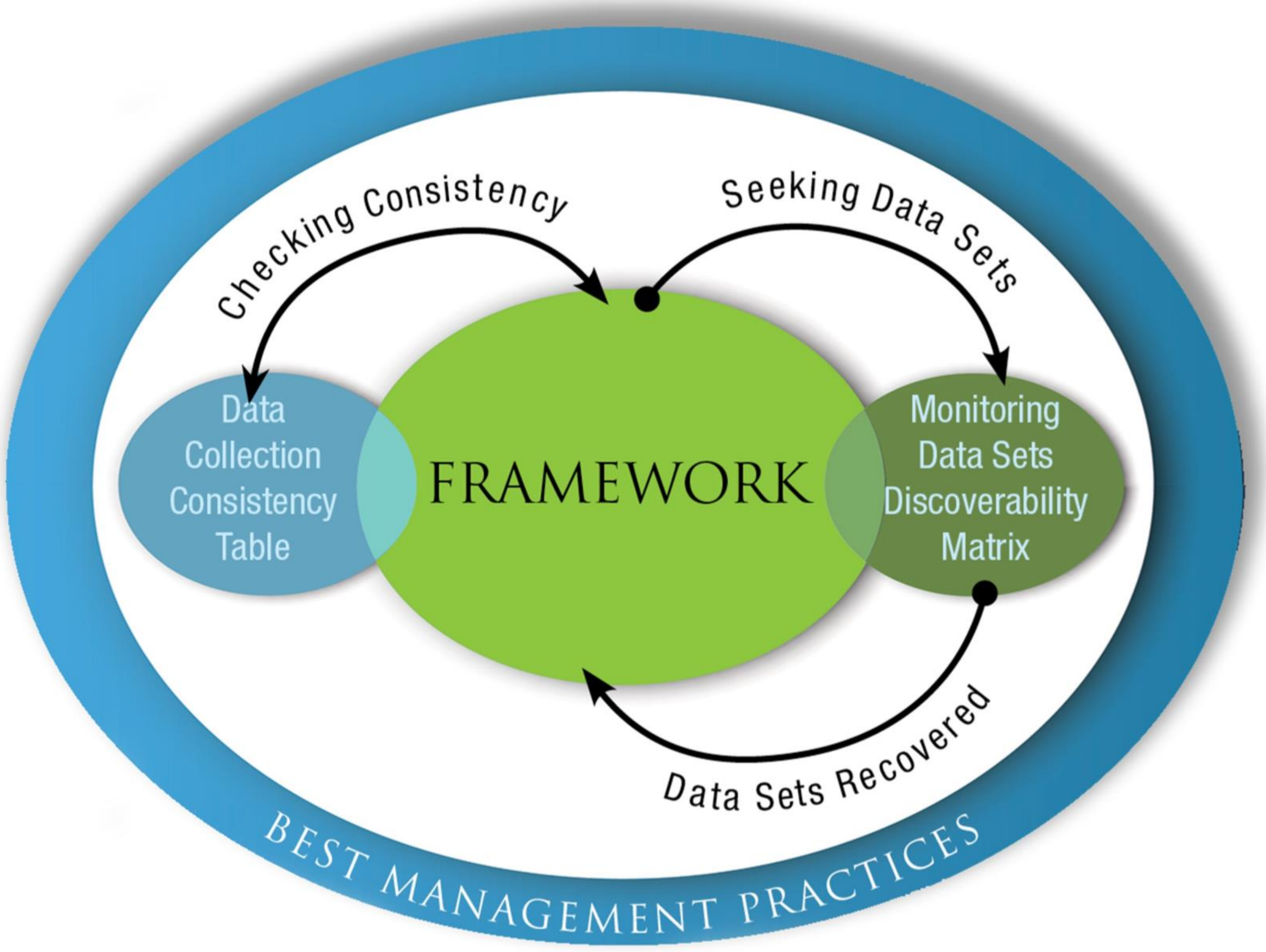
- Need to ensure datasets from permitted projects are readily available and able to be compared



Data Transferability and Collection Consistency

- What do we mean by “data transferability”
- What about “data collection consistency”?
- Our hypothesis is that:
  - Data/information collected through research studies and monitoring from other projects should inform new projects.
  - Site specific data will be needed for all new projects.
  - But – the data from established projects may reduce site specific data collection needs.
  - And, similarities to other industries may inform new MRE projects.
  - These data that might be “transferred” need to be collected consistently for comparison.

Data Transferability Process

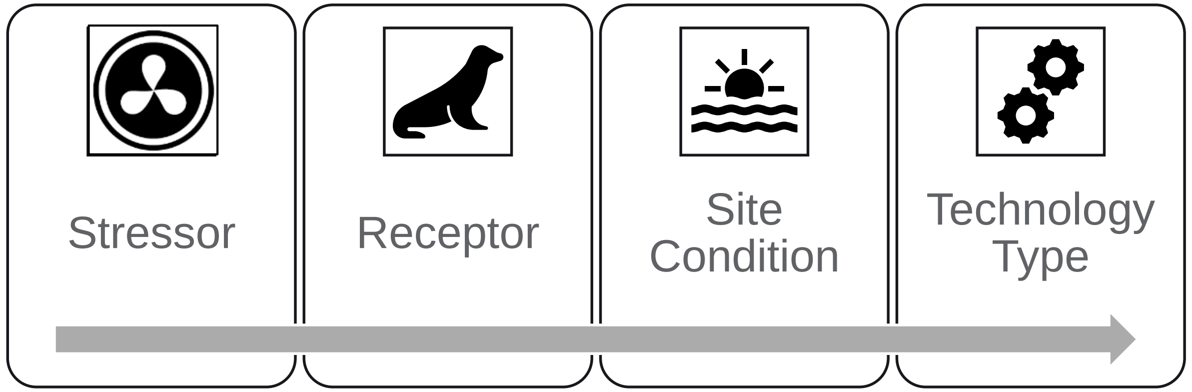


Framework for Data Transferability

1. Brings together datasets from already permitted/consented projects in an organized fashion
2. Compares the applicability of each dataset for use in permitting/consenting future projects
3. Assures data collection consistency through preferred measurement methods or processes
4. Guides the process for data transfer

- Uses stressors to categorize framework:
  - Collision risk
  - Underwater noise
  - EMF
  - Habitat changes
  - Changes to physical systems
  - Barrier effects

- Four variables to define an interaction



Guidelines for Transferability

Necessary

- Interaction defined by same 4 variables and data collected consistently
- Same project size (single or array)

Important

- Same receptor species (or closely related)
- Similar technology

Desirable

- Similar wave/tidal resource

Information on Underwater Noise from MRE Devices

Sound recordings and data courtesy of
Brian Polagye (PMEC), Teresa Simas, (WavEc),
Juan Bald (BIMEP) and partners

Underwater Noise Effects

- Anthropogenic noise from a variety of sources can:
  - Induce behavioral changes (i.e., avoidance/attraction)
  - Cause physical harm
- Shipping and other industries produce higher-amplitude noise (much louder) than MRE
- Offshore renewables: noise concerns from construction; operational noise likely to be much lower
- Unlikely for noise from MRE to cause harm to marine animals

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U.S. Regulatory Thresholds

Marine Mammals

- NOAA Technical Guidance (2018)

Table 6: **TTS onset thresholds for non-impulsive sounds.**

Hearing Group	K (dB)	C (dB)	Weighted TTS onset acoustic threshold (SEL_{cum})
Low-frequency (LF) cetaceans	179	0.13	179 dB
Mid-frequency (MF) cetaceans	177	1.20	178 dB
High-frequency (HF) cetaceans	152	1.36	153 dB
Phocid pinnipeds (underwater)	180	0.75	181 dB
Otariid pinnipeds (underwater)	198	0.64	199 dB

Table 4: **Summary of PTS onset thresholds.**

	PTS Onset Thresholds* (Received Level)	
Hearing Group	**Impulsive**	**Non-impulsive**
Low-Frequency (LF) Cetaceans	*Cell 1* $L_{pk,flat}$: 219 dB $L_{E,LF,24h}$: 183 dB	*Cell 2* $L_{E,LF,24h}$: 199 dB
Mid-Frequency (MF) Cetaceans	*Cell 3* $L_{pk,flat}$: 230 dB $L_{E,MF,24h}$: 185 dB	*Cell 4* $L_{E,MF,24h}$: 198 dB
High-Frequency (HF) Cetaceans	*Cell 5* $L_{pk,flat}$: 202 dB $L_{E,HF,24h}$: 155 dB	*Cell 6* $L_{E,HF,24h}$: 173 dB
Phocid Pinnipeds (PW) (Underwater)	*Cell 7* $L_{pk,flat}$: 218 dB $L_{E,PW,24h}$: 185 dB	*Cell 8* $L_{E,PW,24h}$: 201 dB
Otariid Pinnipeds (OW) (Underwater)	*Cell 9* $L_{pk,flat}$: 232 dB $L_{E,OW,24h}$: 203 dB	*Cell 10* $L_{E,OW,24h}$: 219 dB

Fish

- NOAA Fisheries (salmon & bull trout)
- BOEM Underwater Acoustic Modeling Report (2013)

Table 3. **Interim Fisheries Cause and Effect Guidelines**

	Criteria Level	Type
Physiological Effects	206 dBL re 1 μPa	Absolute Peak SPL
	187 dBL re 1 $\mu Pa^2 s$	SEL_{cum}, For fishes above 2 grams (0.07 ounces)
	183 dBL re 1 $\mu Pa^2 s$	SEL_{cum}, For fishes below 2 grams (0.07 ounces)
Behavioral Effects	150 dBL re 1 μPa (RMS)	Absolute
Reference: U.S. Department of the Interior, Bureau of Ocean Energy Management (BOEM). Effects of Noise on Fish, Fisheries, and Invertebrates in the U.S. Atlantic and Arctic from Energy Industry Sound-Generating Activities, Literature Synthesis, 2012		

Noise Measurements from MRE Devices

Project Location	Device Type	Developer, Project/ Device Name	Project Phase	Project Scope	Sound Levels and Pressure Spectral Densities	Organism Type	Results
Strangford Lough, Northern Ireland	Tidal; two 16 m open-bladed rotors, attached to a pile in the seabed in 26.2 m of water	MCT (Marine Current Turbines) SeaGen™	Ambient	Used hydrophones to measure ambient noise	Range of 115 to 125 dB re 1 µPa	NA	High frequencies (200 Hz – 70 kHz) attributed to sound of tidal flow.
			Construction	Measure noise levels of construction activities and marine mammal response to construction noise	• Driving pin-piles: 136 dB 1 µPa at 28 m; 110 dB 1 µPa at 2130 m • Drilling: 20-100 Hz. Equiv. to background noise at 464 m	Harbor porpoise	Temporary displacement of harbor porpoises during construction. Baseline abundances resumed following completion of construction.
			Construction	Calculate the perceived noise levels by marine animals during drilling	• Harbor seal: 59 dB_{ht} at 28 m and 30 dB_{ht} at 2130 m • Herring: 62 dB_{ht} at 28 m and 25 dB_{ht} at 2130 m	Harbor seals, harbor porpoise, herring, dab, trout	Perceived levels of sound from pin-pile driller were generally lower than ambient levels of sound in the narrows. Calculations of perceived noise suggest marine animals in Strangford Lough were unlikely to be disturbed at distances more than 115 m from drilling.
			Operation	Determine harbor seal behavior in area of operating device	Ambient plus device signature	Harbor seals	No significant displacement of seals or porpoises. Marine mammals swam freely in the Lough during operation. Noted evasion at channel center during turbine operation.
Cobscook Bay, Maine, USA	Tidal; a single, barge-mounted, cross-axis turbine generator unit in 26m of water	Ocean Renewable Power Company, Cobscook Bay Tidal Energy Project	Operation	Measure noise levels of the barge-mounted turbine	Less than 100 dB re $\mu Pa^2/Hz$ at 10m	NA	At 200 to 500 m from the turbine, sound was not detectable above ambient noise within the bay.
East River, New York, USA	Tidal; six three-bladed unducted turbines bottom-mounted in 10 m of water	Verdant Power, Roosevelt Island Tidal Energy Project	Operation	Measure noise levels around the array of tidal turbines	Up to 145 dB re 1µPa @ 1m from the array	14 fish species in the area	During the study, blades on one turbine were broken and another turbine was failing, resulting in more noise generation than would be expected. Conclude sound at damaged turbine array did not reach levels known to cause injury for 13 species of fish examined.
Puget Sound, Washington, USA	Wave; 1/7th-scale wave buoy	Columbia Power Technologies, SeaRay™	Ambient and Operation	Measure sound signature of the wave device and surrounding area	• Ambient: 116-132 dB re 1µPa in frequency of 20 Hz to 20 kHz when ships were nearby. • Device: 126 dB re 1µPa	NA	Ambient noise levels masked the wave device sound. Sound from the SeaRay was closely correlated to the wave period.

State of the Science Report (Copping et al. 2016)

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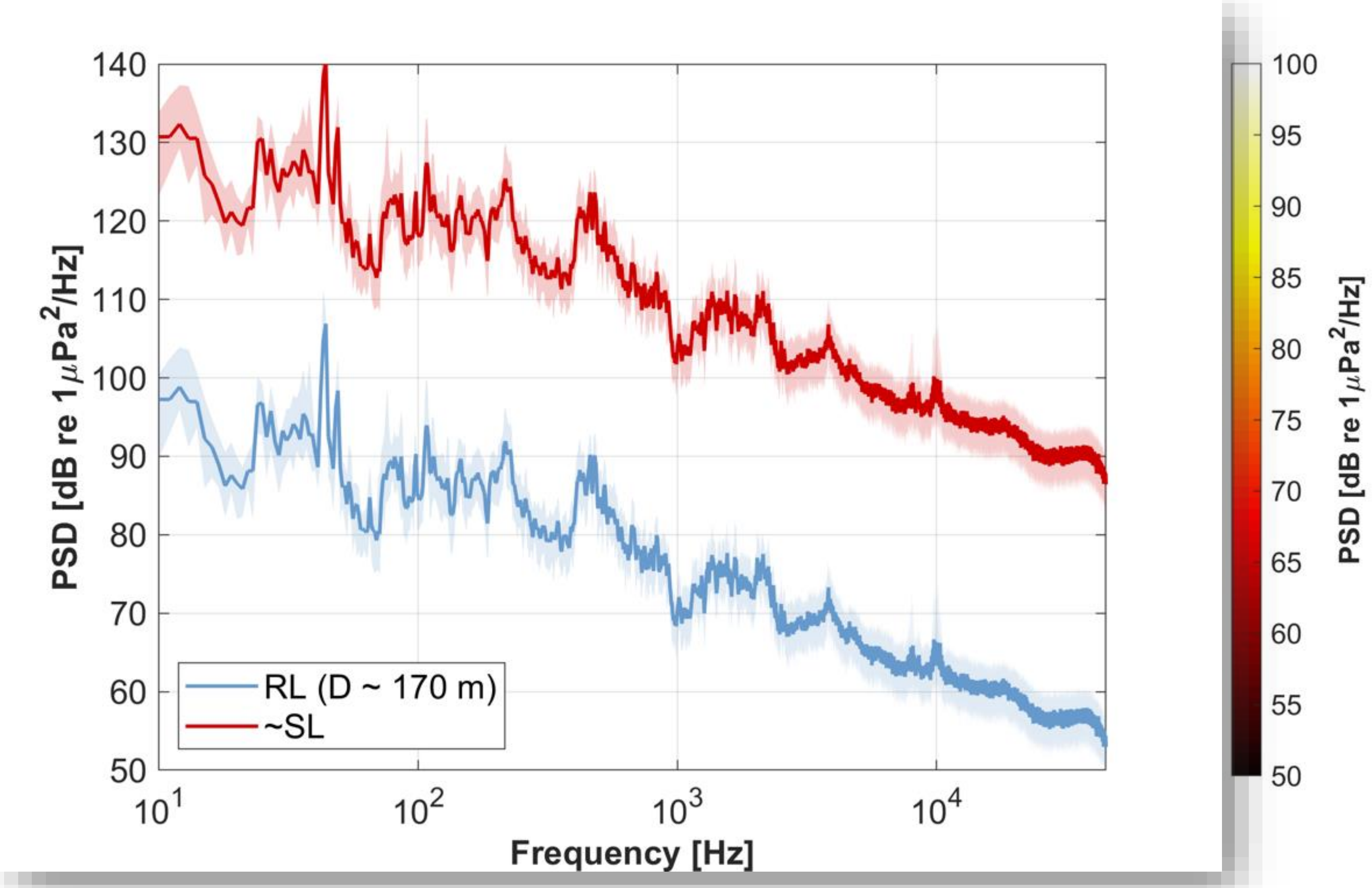
OpenHydro Turbine at EMEC

- European Marine Energy Centre (EMEC), Fall of Warness
- Noise from rotor, power take off, and “seal scarer”
- Broadband (10 Hz – 45 kHz) SL = 150 dB



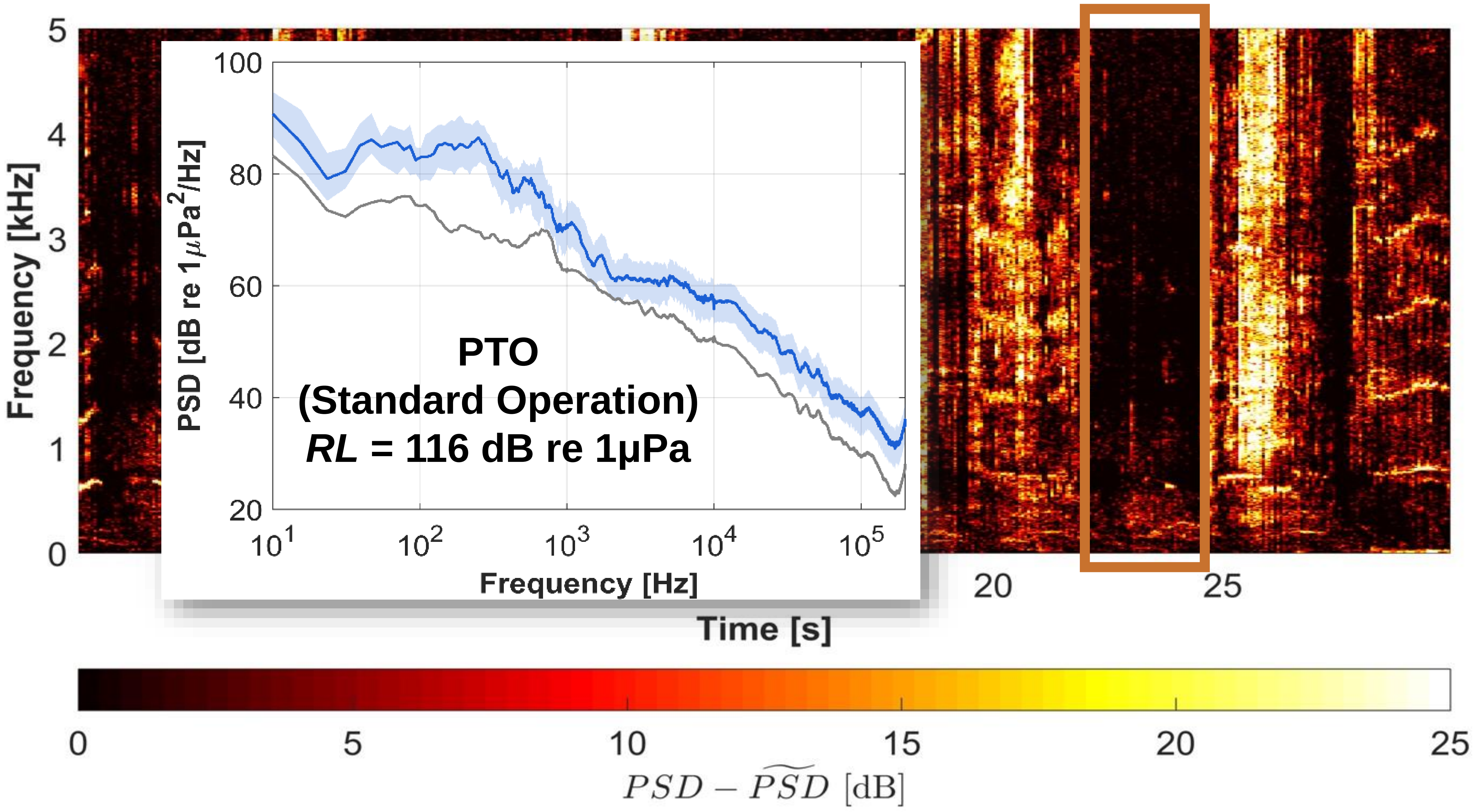
(Polagye et al. 2017, pers. com.)

Fred. Olsen Lifesaver at WETS

- Hawai’i Wave Energy Test Site (WETS), O’ahu, HW, U.S.
- Floating point absorber
- Shallow draft (0.5 m)
- Noise measurements (2016):
  - 3 seabed-mounted hydrophones (3 months)
  - 2 drifting hydrophones (3 drifts)

(Polagye et al. 2017, EWTEC)

Fred. Olsen Lifesaver at WETS



(Polagye et al. 2017, EWTEC)

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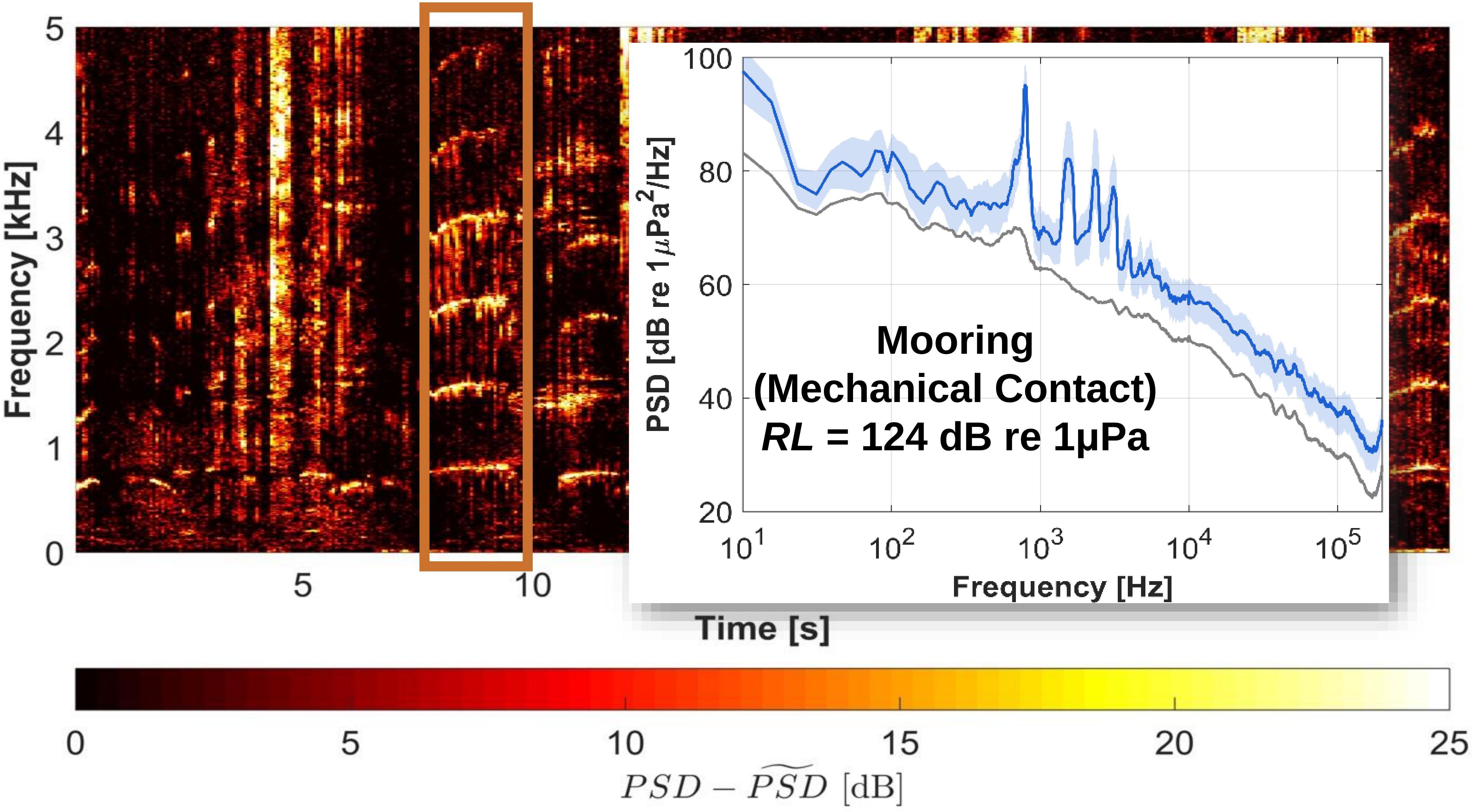
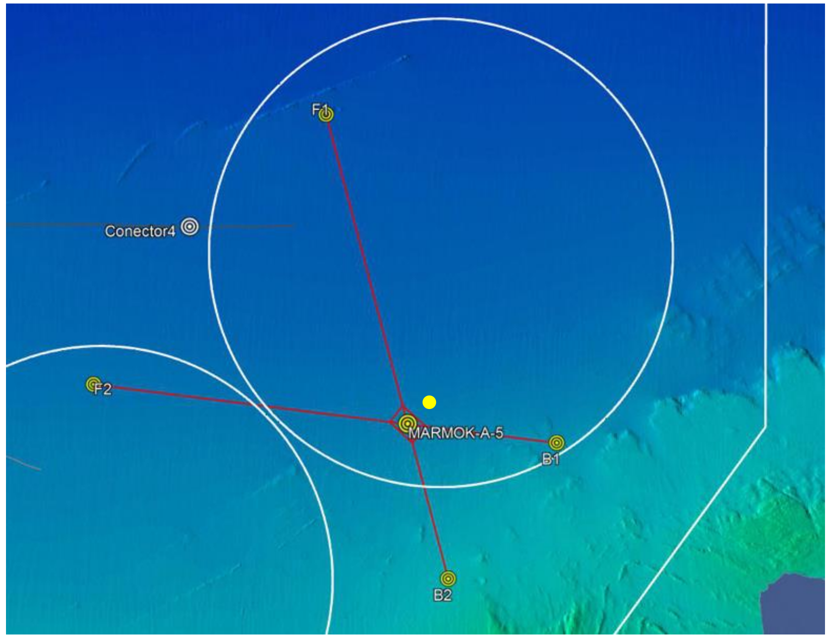


(Polagye et al. 2017, EWTEC)

IDOM’s MARMOK-A-5 at BiMEP

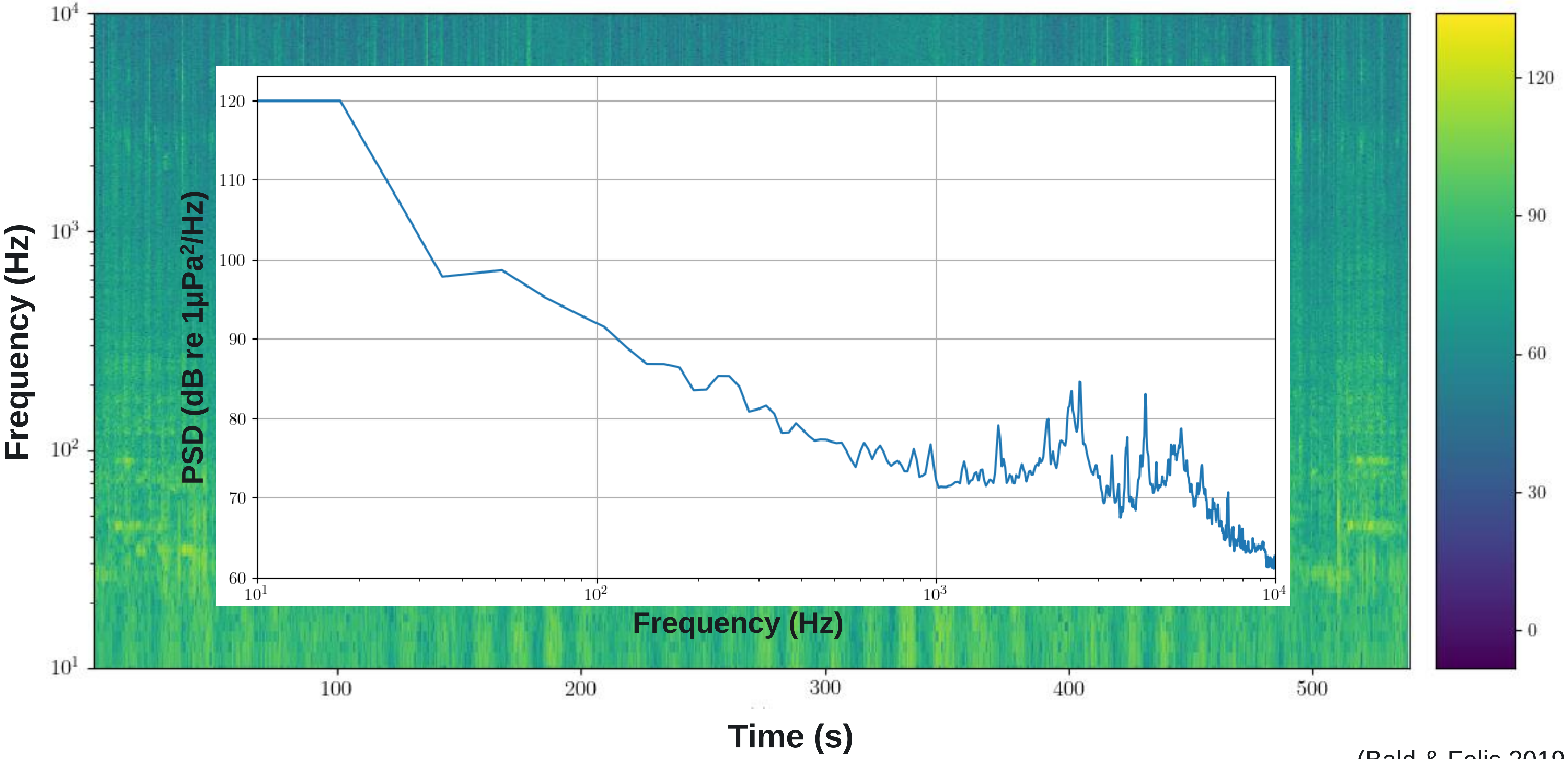
- Biscay Marine Energy Platform, Armintza Test Site, Spain
- Oscillating water column
- Noise measurements (WESE Project, 2019):
  - 1 seabed-mounted hydrophone at ≈ 100 m from device
  - Continuous recording for 44 days



(Bald 2019, pers. com.)

IDOM's MARMOK-A-5 at BiMEP

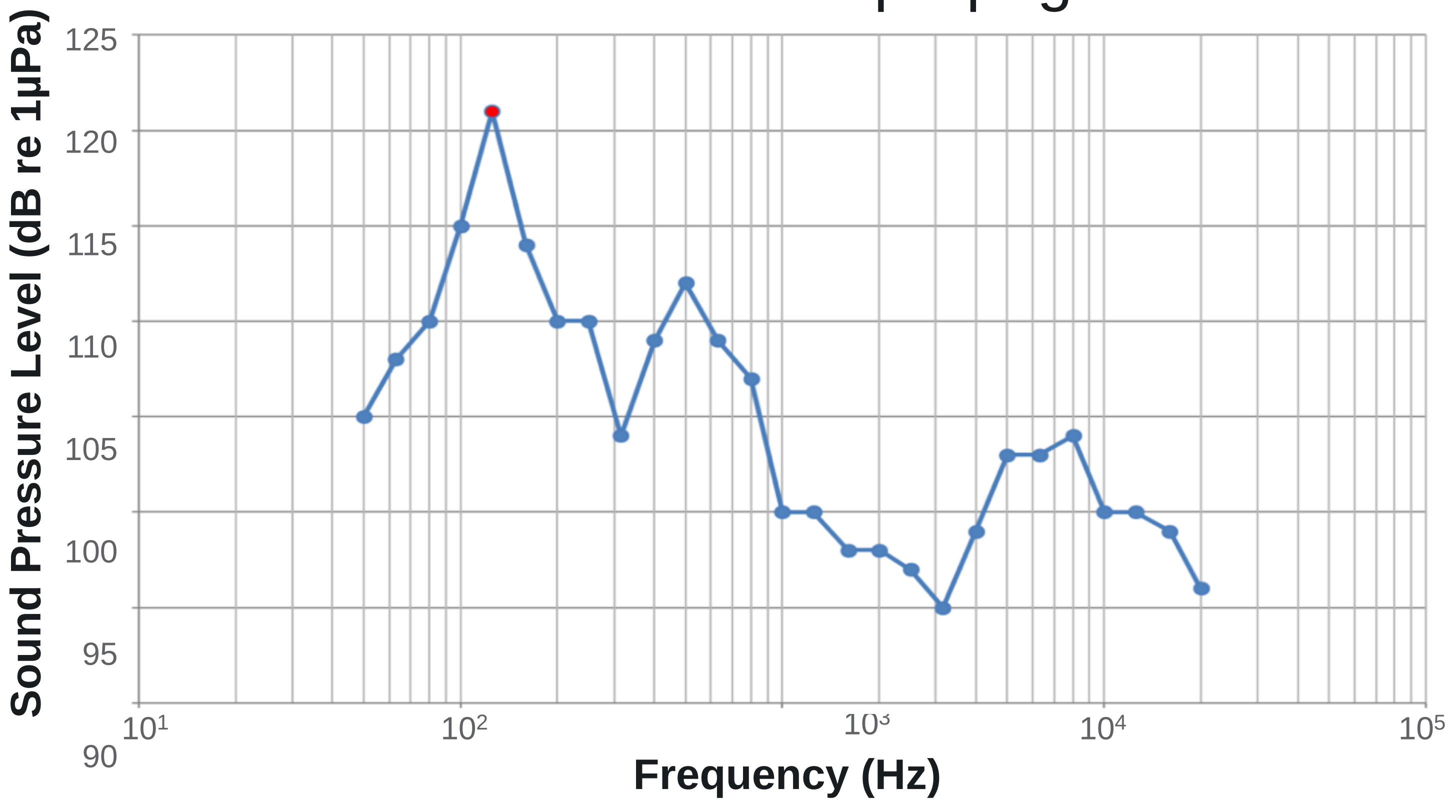
- Mooring line is dominant noise in 5 m wave height



(Bald & Felis 2019, pers. com.)

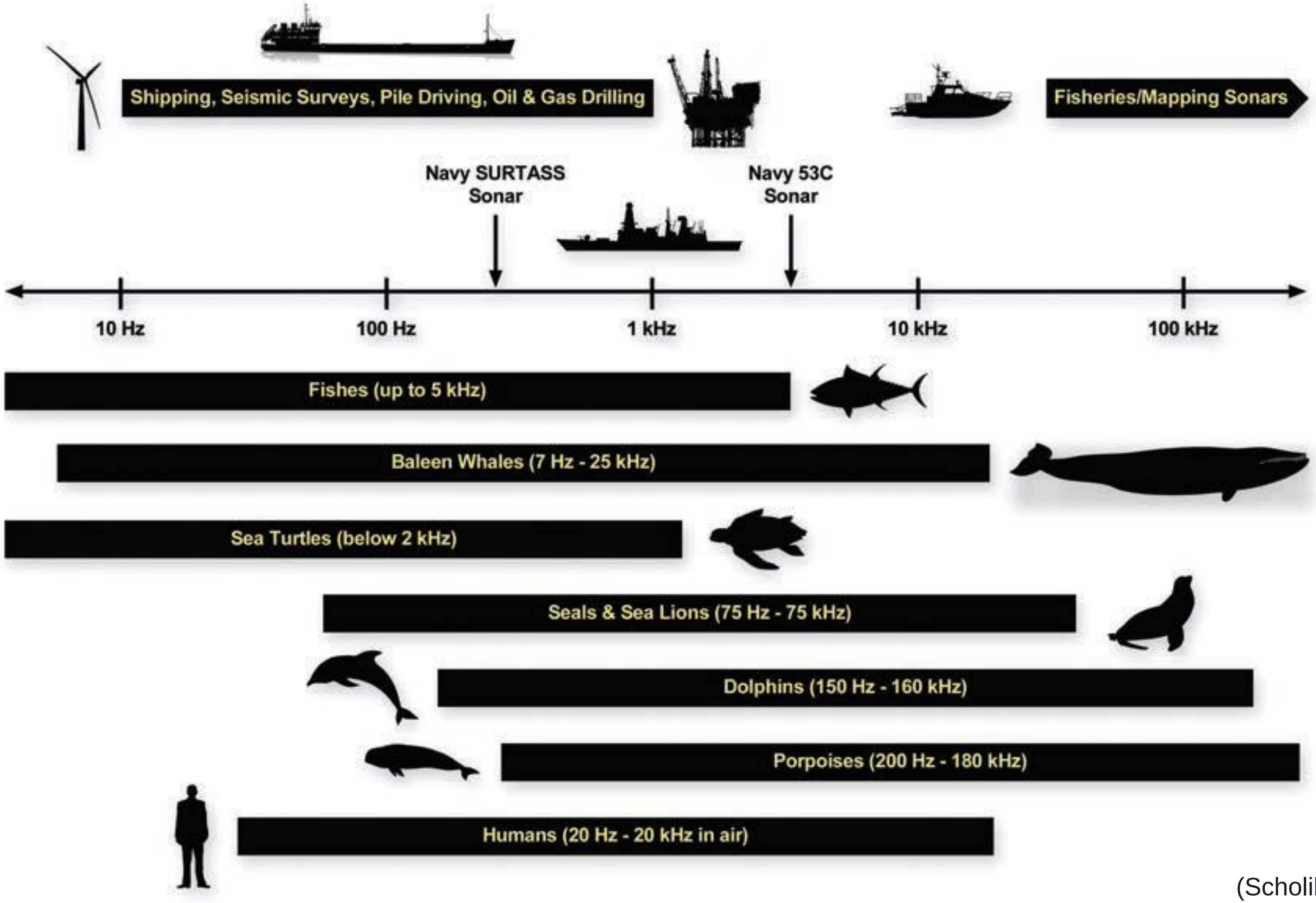
WaveRoller at WavEc

- WavEc Offshore Energy Test Site, Peniche, Portugal
- Oscillating wave surge converter, bottom-mounted
- Noise measurements (2014):
  - 2 seabed-mounted hydrophones (24 h)
  - Sound characterization & propagation measurements



(Cruz et al. 2015, EWTEC)

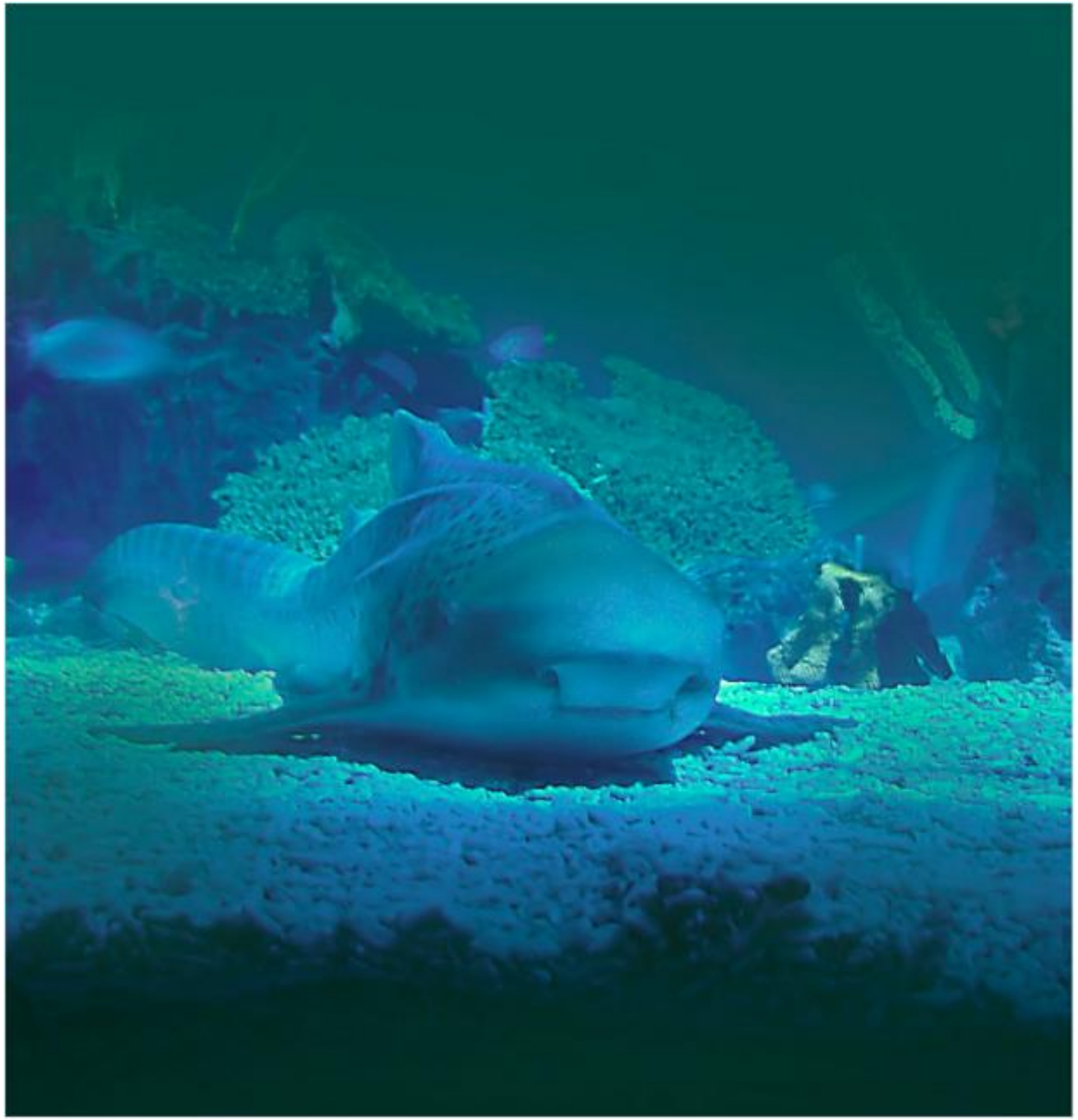
Hearing Thresholds vs. Underwater Noise Levels



(Scholik-Schlomer 2015)

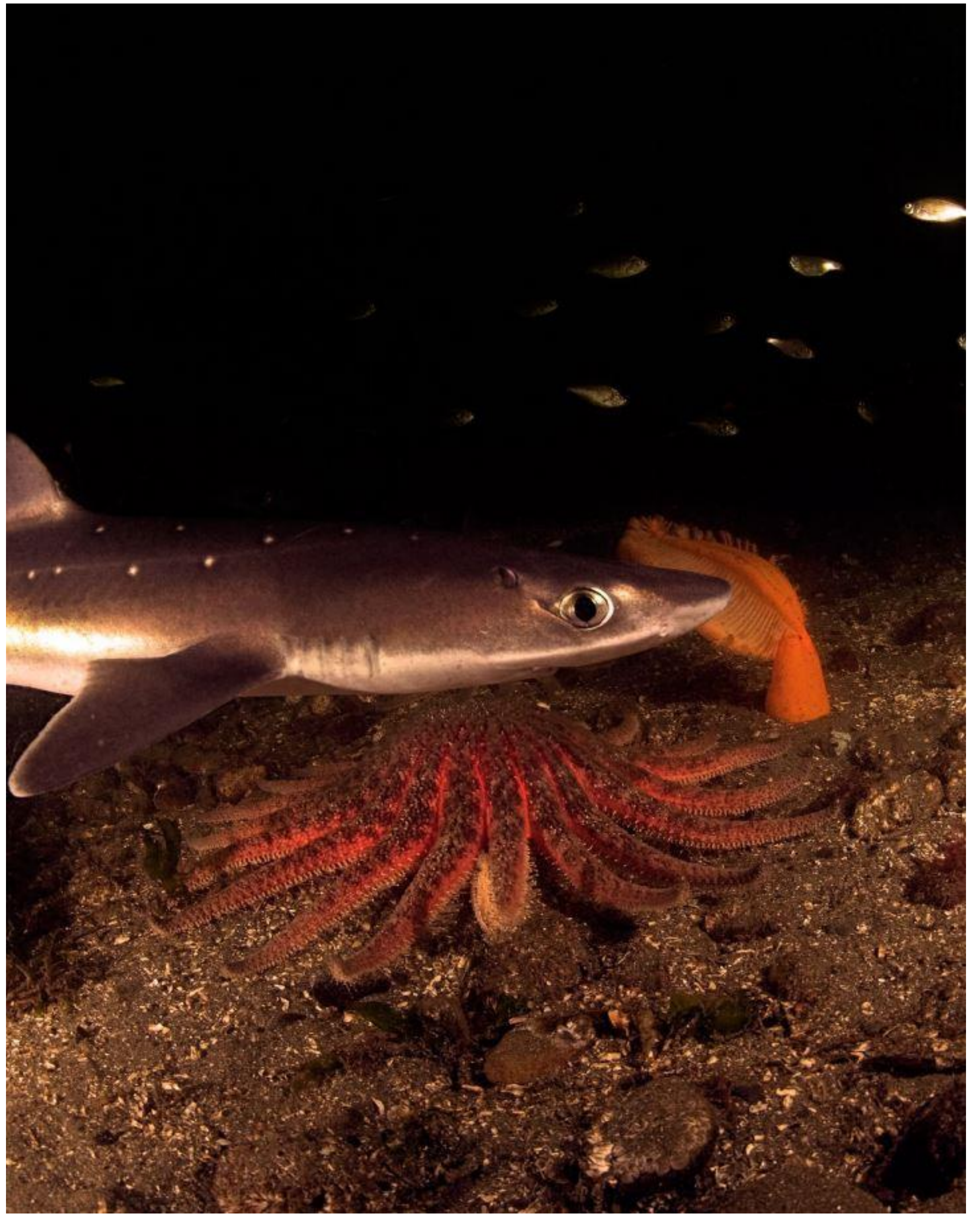
Information on EMF Impacts on Marine Animals from Exports Power Cables

Credit to Ann Bull, BOEM for many of the slides
And many many researchers



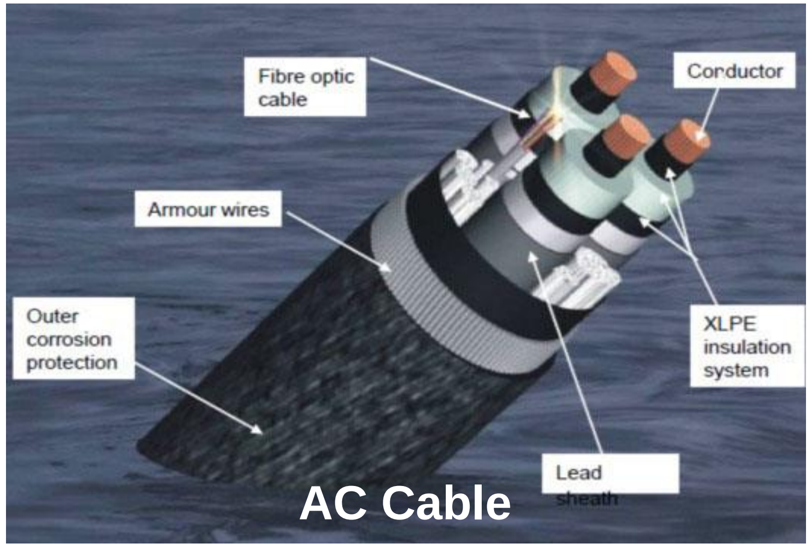
Electromagnetic Fields (EMF) Effects

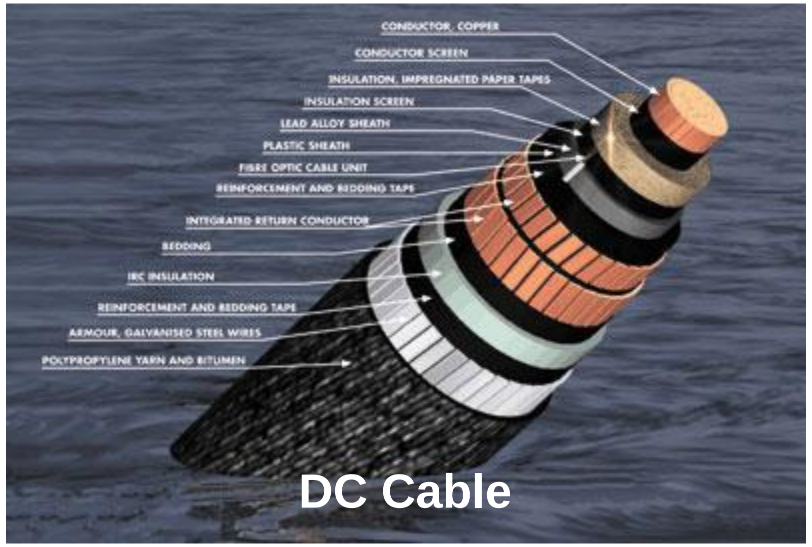
- Anthropogenic EMF come from a variety of marine infrastructure (e.g., subsea cables, bridges, tunnels)
- MRE emits EMF from power cables, devices' moving parts, and substations/transformers
- EMF may affect organisms that use natural magnetic fields for orientation, navigation, and/or hunting (e.g., elasmobranchs, marine mammals, crustaceans, sea turtles, and some fish species)
- EMF-sensitive species can be attracted to or avoid sources of EMF
- No demonstratable impact of EMF related to MRE devices on any sensitive species



EMF from AC and DC Power Cables

- Similar to cables used in the offshore wind industry
  - Export cable is typically 132kV AC cable (up to 250MW)
  - Inter-array cables are typically 33kV AC cables
  - Where possible, cables are buried to 1-3m depth
  - Industry starting to use large DC cables for distances greater than 80km (less transmission loss)
- Cables used by MRE projects
  - Size varies by project, but all smaller than typical wind
  - Most common cable is 11kV AC, buried to 1m depth
- All cables are electrically shielded, but the magnetic field is not blocked and generates an induced electric field





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EMF Fields Studies


COWRIE

March 2009

COWRIE 2.0 Electromagnetic Fields (EMF) Phase 2

Fisheries Management and Ecology

Sub-sea power cables and the migration behaviour of the European eel

H. WESTERBERG & I. LAGENFELT

EMF-sensitive fish response to EM emissions from subsea electricity cables (Gill et al. 2009)

- West Scotland, 2007, 125 kV AC cable buried 0.5-1m
- Mesocosms with energized and control cables (3 trials)
- No evidence of positive or negative effect on catsharks (dogfish)
- Benthic elasmobranchs (skates) responded to EMF from cable

Sub-sea power cables and the migration behaviour of the European eel (Westerberg and Lagenfelt 2008)

- East Sweden, 2006, unburied 130 kV AC cable
- Used acoustic tags to track movements of 60 eels
- Eels swam more slowly over energized cable
- Effect was small, no evidence of barrier effect

EMF Fields Studies

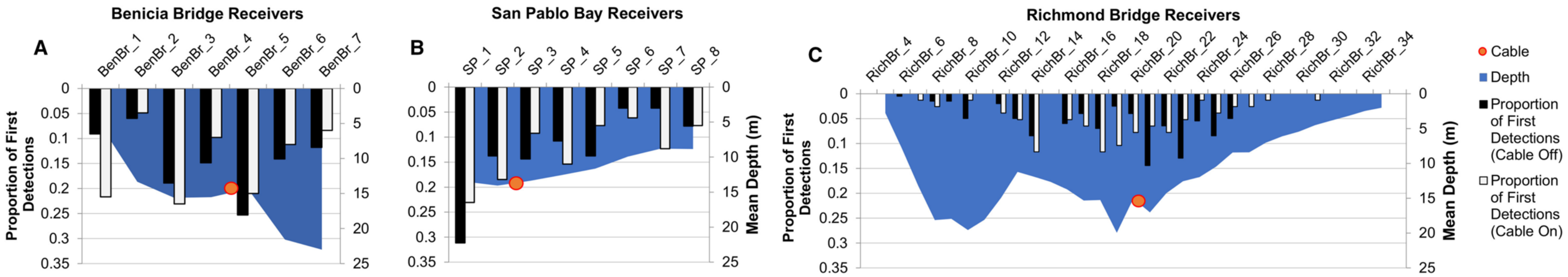
Assessment of potential impact of electromagnetic fields (EMF) from undersea cable on migratory fish behavior (Kavet et al. 2016)

- West U.S., 2014, buried 200 kV DC cable
- HVDC cable in San Francisco Bay, parallel or perpendicular to green & white sturgeon, salmon, and steelhead smolt migrations
- Tagged fish, magnetometer surveys
- Outcome – such large magnetic signatures from bridges, other infrastructure, could not distinguish cable!
- Fish did not appear to be affected

EMF Fields Studies

Behavioral responses by migrating juvenile salmonids to a subsea high-voltage DC power cable (Wyman et al. 2018)

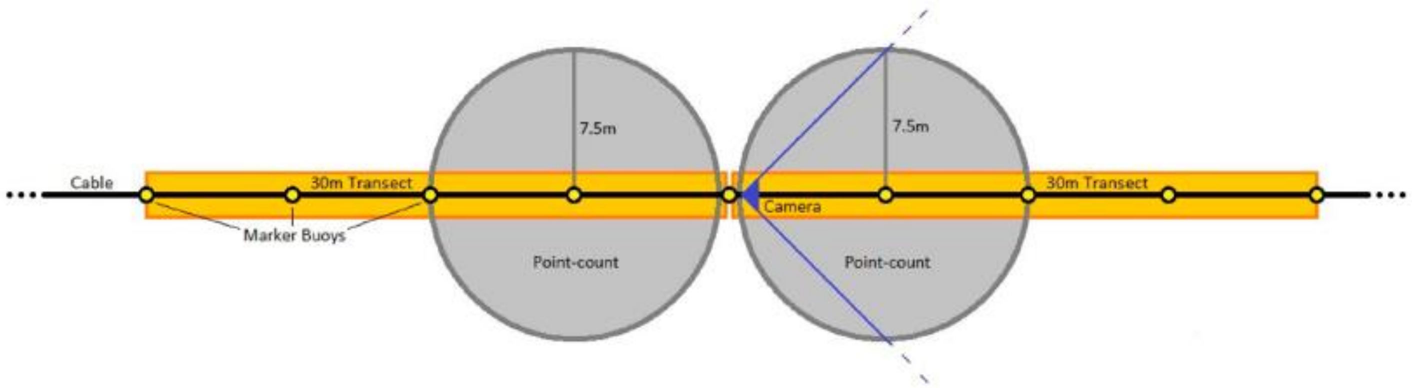
- West U.S., 2014, buried 200 kV DC cable
- Before and after energization of Trans Bay Cable (HVDC cable in San Francisco Bay)
- Tagged Chinook salmon smolts successfully migrated through the bay before and after cable energization without significant differences
- Cable activity was not associated with the probability of successfully exiting the system, or crossing the cable location

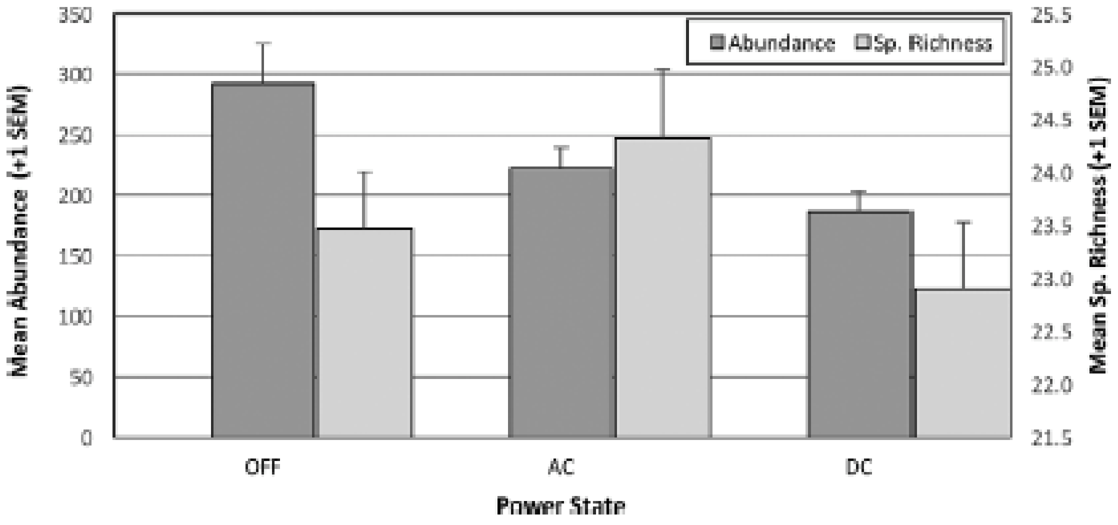


EMF Fields Studies

Effects of EMF emissions from undersea electric cables on coral reef fish (Kilfoyle et al. 2018)

- SE U.S., 2014, 5-15m deep, unburied cables
- Blind randomized sequence of ambient and energized AC and DC cable power states
- In situ observations of fish abundance and behavior ("unusual" or unexpected movements or reaction)
- No behavioral changes were noted in immediate responses to alterations in EMF
- No statistical differences in fish abundance among the power states

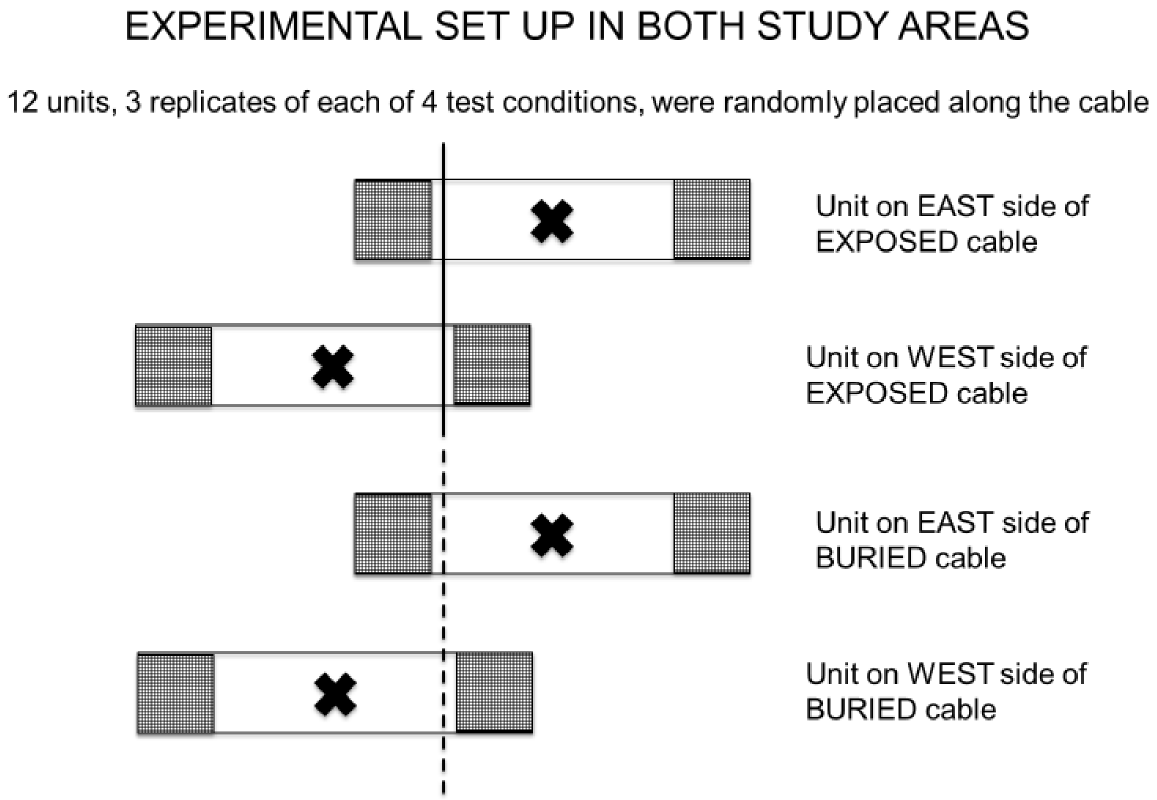




EMF Fields Studies

Potential impacts of submarine power cables on crab harvest (Love et al. 2017)

- NW U.S. and SW U.S., 2015, 10-13m deep, unburied power cables
- Will rock crab (Santa Barbara channel) and Dungeness crab (Puget Sound) cross a power cable?
- Rock crabs cross an unburied 35 kV AC power cable
- Dungeness crabs cross an unburied 69 kV AC power cable to enter baited commercial traps



EMF Fields Studies

Electromagnetic field impacts on elasmobranch and American lobster movement and migration from direct current cables (Hutchison et al. 2018)

- NE U.S., 2016, 10m deep, buried 300 kV DC cable
- Determine if EMF-sensitive animals react to HVDC cable:
  - Enclosures with animals using acoustic telemetry tags
- AC components measured from DC cable
- Lobster – statistically significant, but subtle change in behavior
- Skate – strong behavioral response, results suggested an increase in exploratory activity and/or area restricted foraging behavior with EMF
- EMF from cable didn't act as a barrier to movement for either species

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Thank you!

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