
Filling Data Gaps on
EMF and Marine Organisms

BOEM
Bureau of Ocean Energy Management

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Tethys Annex IV Environmental Webinar

May 7, 2015

BOEM Program Goals for Ocean Energy Studies

- Acquire the information needed for assessment and management of environmental impacts.
  - Predict impacts on the marine biota
  - Monitor human, marine, and coastal environments


BOEM-Supported Efforts
Filling Data Gaps
Pacific Coast

3 BOEM-Funded Pacific Studies Related to EMF

- #1 Completed — Effects of EMFs from Undersea Power Cables on Elasmobranchs and Other Marine Species
  www.data.boem.gov/PI/PDFImages/ESPIS/4/5115.pdf

- #2 Summer 2015 — Renewable Energy *in situ* Power Cable Observation
  www.boem.gov/pc-11-03/

- #3 Summer 2017 — Potential Impacts of Submarine Power Cables on Crab Harvest
  www.boem.gov/pc-14-02/

BOEM-Supported Efforts
Filling Data Gaps
Pacific Coast
Study #1

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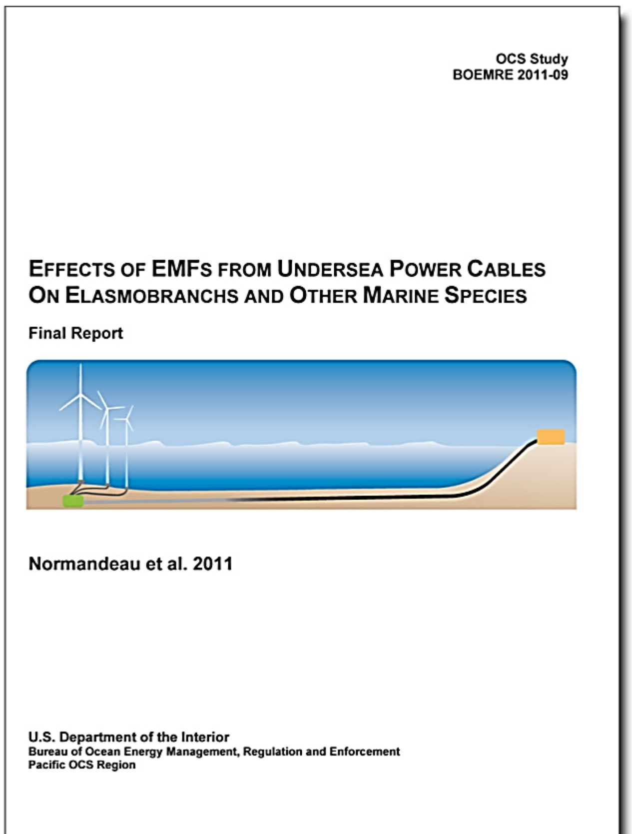
EMF Study #1

Effects of EMFs from Undersea Power Cables on Elasmobranchs and Other Marine Species

What does the literature say?


OCS Study
BOEMRE 2011-09

EFFECTS OF EMFS FROM UNDERSEA POWER CABLES
ON ELASMOBRANCHS AND OTHER MARINE SPECIES

Final Report

Normandeau et al. 2011

U.S. Department of the Interior
Bureau of Ocean Energy Management, Regulation and Enforcement
Pacific OCS Region

Objectives:

- Describe and quantify predicted EMF from power cables connected to offshore renewable energy projects.
- Compile information on sensitive marine species that have the potential for exposure effects.
- Understand sensitive marine species and the potential effects of exposure to EMFs from offshore power cables.

EMF Study #1

Methods:

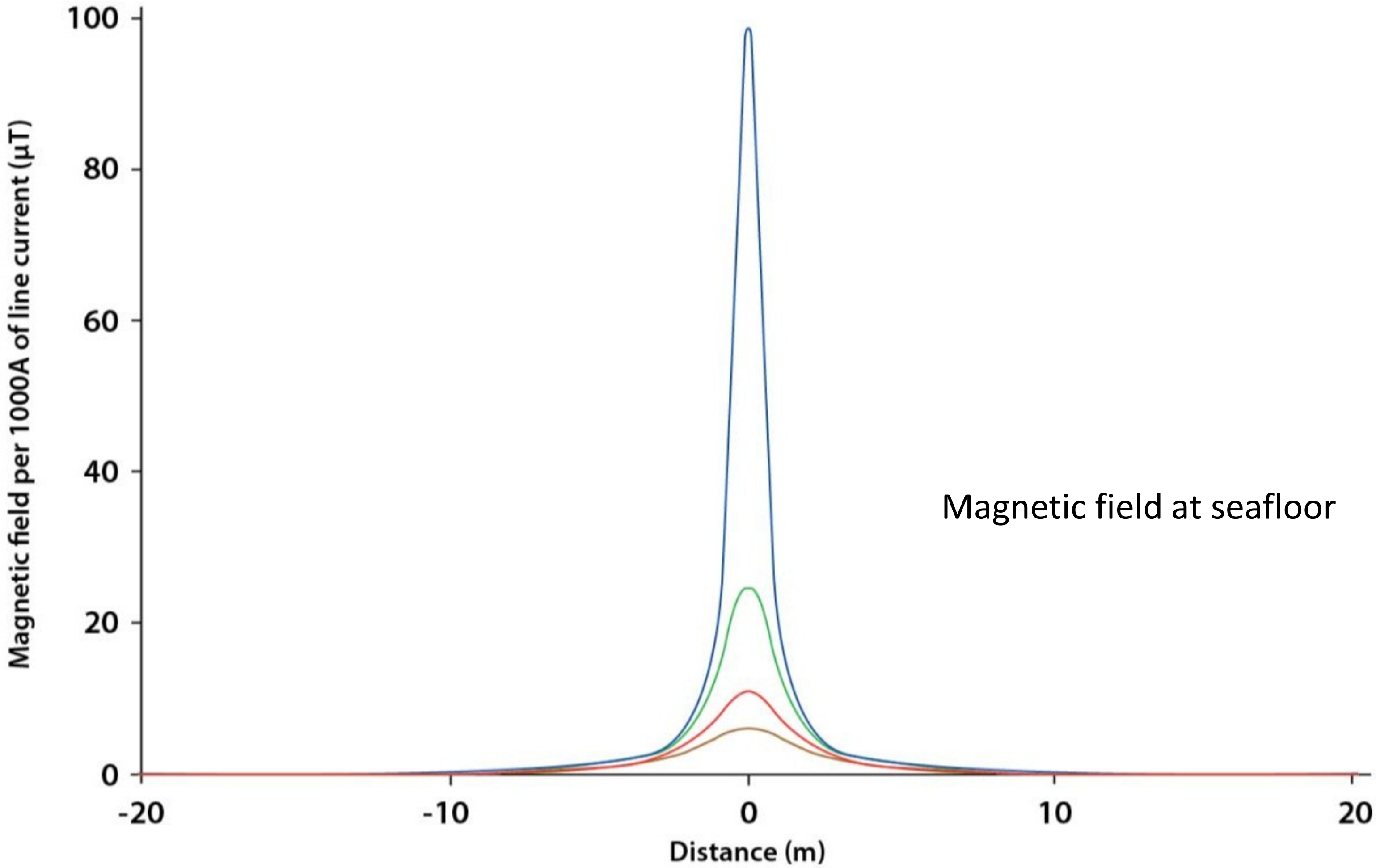
Table 4.2-1

Listing of elasmobranch species for which information on sensitivity to electric or magnetic fields has been reported.

Species[a]	Common Name	US ?[b]	Sensitivity	Sensory Range	Evidence Basis	Citation
Class Chondrichthyes, Subclass Elasmobranchii: sharks, skates, and rays						
Order Orectolobiformes, Family Ginglymostomatidae: nurse sharks						
Ginglymostoma cirratum	nurse shark	US	E	frequency: DC fields and AC fields <1.6 Hz	Behavioral	Johnson et al. 1984
Order Lamniformes, Family Lamnidae: mackerel sharks						
Carcharodon carcharias	white shark	US	E/M?	geomagnetic field/electric field sensitivity n/a	Behavioral/ observational/ anatomical/ theoretical	Klimley et al. 2002, Tricas 2001, Tricas and McCosker 1984
Isurus oxyrinchus	shortfin mako	US	E/M?	geomagnetic field/electric field sensitivity n/a	Behavioral/ observational	Klimley et al. 2002
Order Carcharhiniformes, Family Scyliorhinidae: cat sharks						
Cephaloscyllium isabellum	carpet shark	Not in US	E	2µV/cm	Physiological/ behavioral	Bodznick and Montgomery 1992, Yano et al. 2000
Cephaloscyllium ventriosum	swell shark	US	E	n/a	Behavioral	Tricas 1982
Scyliorhinus canicula	small-spotted cat shark	Not in US	E	0.01 to 0.1 µV/cm	Behavioral/ physiological	Filer et al. 2008, Gill and Taylor 2001, Gill et al. 2009, Kalmijn 1966, Kalmijn 1971, Kimber et al. 2009, Pals et al. 1982a, Peters and Evers 1985
Scyliorhinus torazame	cloudy catshark	Not in US	E	0.2-10V and 0.1-5A, DC	Behavioral	Yano et al. 2000

EMF Study #1

Model:



Adapted from Normandeau et al. (2011)

Appendix Table B-1. Summary of information on existing and proposed undersea power cables.

Existing and proposed undersea power cables.

Year	Name	Country	Landfalls	Waterway	Length (km)	Frequency (Hz)	Voltage (KV)	Maximum Capacity (MW)	Calcs[a]	Marine Assess[b]
Existing Power Cables										
1969	1385 Line Cable System (NU/LIPA	US	Norwalk, CT Northport, NY	Norwalk Harbor/Long Island Sound	11.7	60	138	300	-	-
1996	Nantucket Cable #1	US	Harwich, MA Nantucket Is, MA	Nantucket Sound (Horseshoe Shoal)	26	60	46	35	Y	N
1998	Haines Scagway Submarine Cable Intertie Project	US	Haines, AK Skagway, AK	Taiya Inlet	24.2	60	35	15	-	-
2000	SwePol Link	SW/POL	Karlshamm, Sweden Slupsk, Poland	Baltic Sea	245 km	0	±450	600 Max	Y	-
2001	?	US	Galeveston, TX Galeveston Island, TX	?	?	60	138	200	?	?
2002	Replacement of 138kV Submarine Electric Transmission Cable System	US	Norwalk, CT Northport, NY	Norwalk Harbor/Long Island Sound	17.7	60	138	300	Y	Y
2002	Cross Sound Cable	US	New Haven, CT Brookhaven, NY	Long Island Sound	38.6	0	± 150	330	Y	Y
2002	San Juan Cable Project	US	Fidalgo Island Lopez Island	Puget Sound	13.5	60	69		-	-
2003	Nysted Offshore Wind Farm	DE	Baltic Sea Nysted, Denmark	Baltic Sea	48 km	50	33 to 132	165.6	-	Y

Some Findings from Literature Study

- Anticipated EMFs from power cables can be modeled easily if specific information is available:
  - Cable design
  - Burial depth and layout
  - Magnetic permeability of the sheathing
  - Loading

- Behavioral responses to and some effects from electro- or magnetic fields are known for a few species; extrapolation to many other species or to population impacts is speculative.


BOEM-Supported Efforts
Filling Data Gaps
Pacific Coast
Study #2

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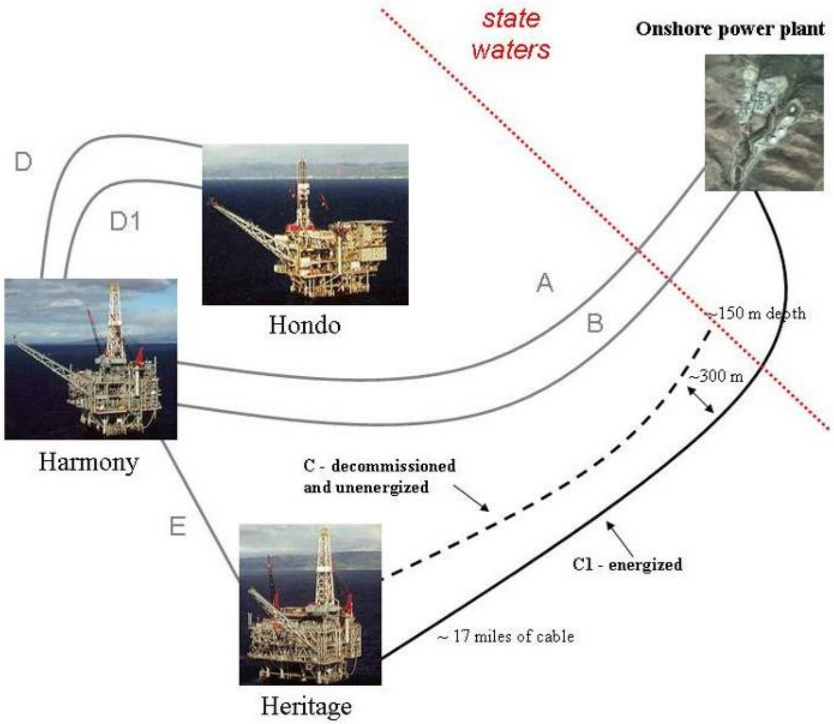
EMF Study #2

Renewable Energy *in situ* Power Cable Observation

Does EMF from a power cable attract/repulse fish or invertebrates?



Identical 35 kV AC Power Cables

Objectives:

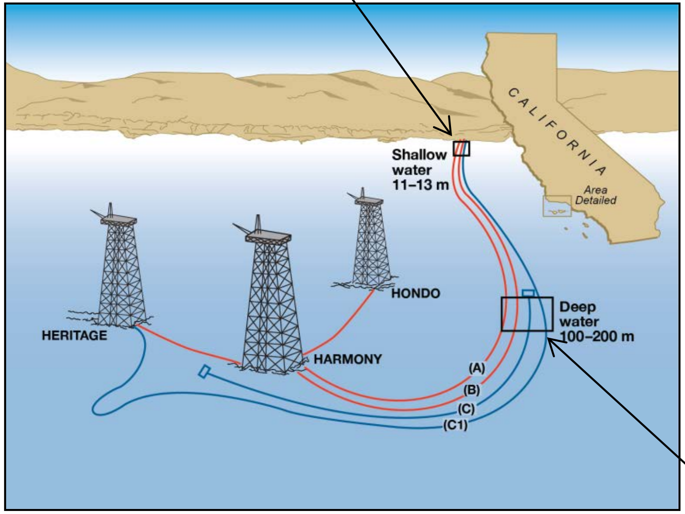
- Measure the strength, spatial extent, and variability of EMFs along both energized and unenergized cables.
- Determine attraction/repulsion of fish and macroinvertebrates to the EMF from the power cables.
- Determine the effectiveness of the commonly proposed mitigation of cable burial.

EMF Study #2

Methods:

Video Surveys using SCUBA

11-13 m depth

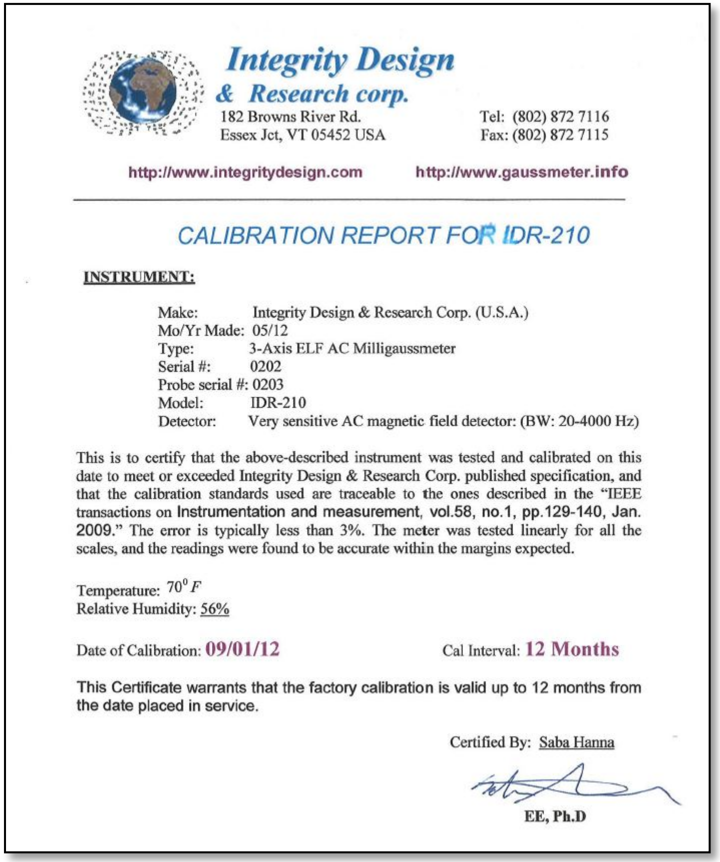


30-150 m depth

Video Surveys using Sub

EMF Study #2

Methods:



Integrity Design & Research corp.

182 Browns River Rd.
Essex Jct, VT 05452 USA

Tel: (802) 872 7116
Fax: (802) 872 7115

http://www.integritydesign.com http://www.gaussmeter.info

CALIBRATION REPORT FOR IDR-210

INSTRUMENT:

Make: Integrity Design & Research Corp. (U.S.A.)
Mo/Yr Made: 05/12
Type: 3-Axis ELF AC Milligaussmeter
Serial #: 0202
Probe serial #: 0203
Model: IDR-210
Detector: Very sensitive AC magnetic field detector: (BW: 20-4000 Hz)

This is to certify that the above-described instrument was tested and calibrated on this date to meet or exceeded Integrity Design & Research Corp. published specification, and that the calibration standards used are traceable to the ones described in the "IEEE transactions on Instrumentation and measurement, vol.58, no.1, pp.129-140, Jan. 2009." The error is typically less than 3%. The meter was tested linearly for all the scales, and the readings were found to be accurate within the margins expected.

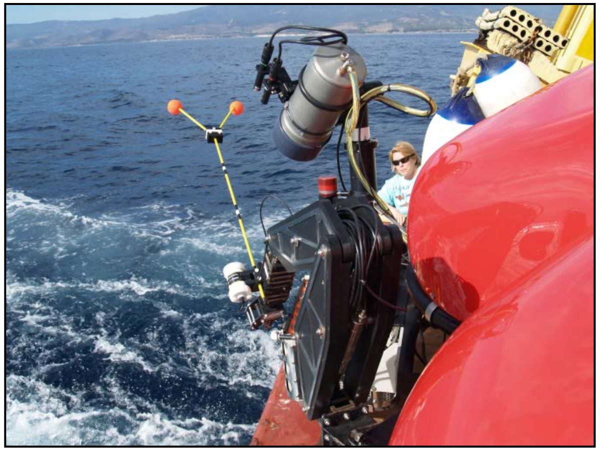
Temperature: $70^0 F$
Relative Humidity: 56%

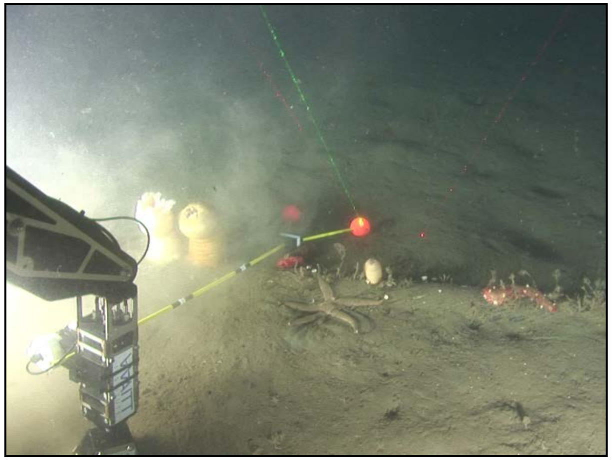
Date of Calibration: 09/01/12 Cal Interval: 12 Months

This Certificate warrants that the factory calibration is valid up to 12 months from the date placed in service.

Certified By: Saba Hanna

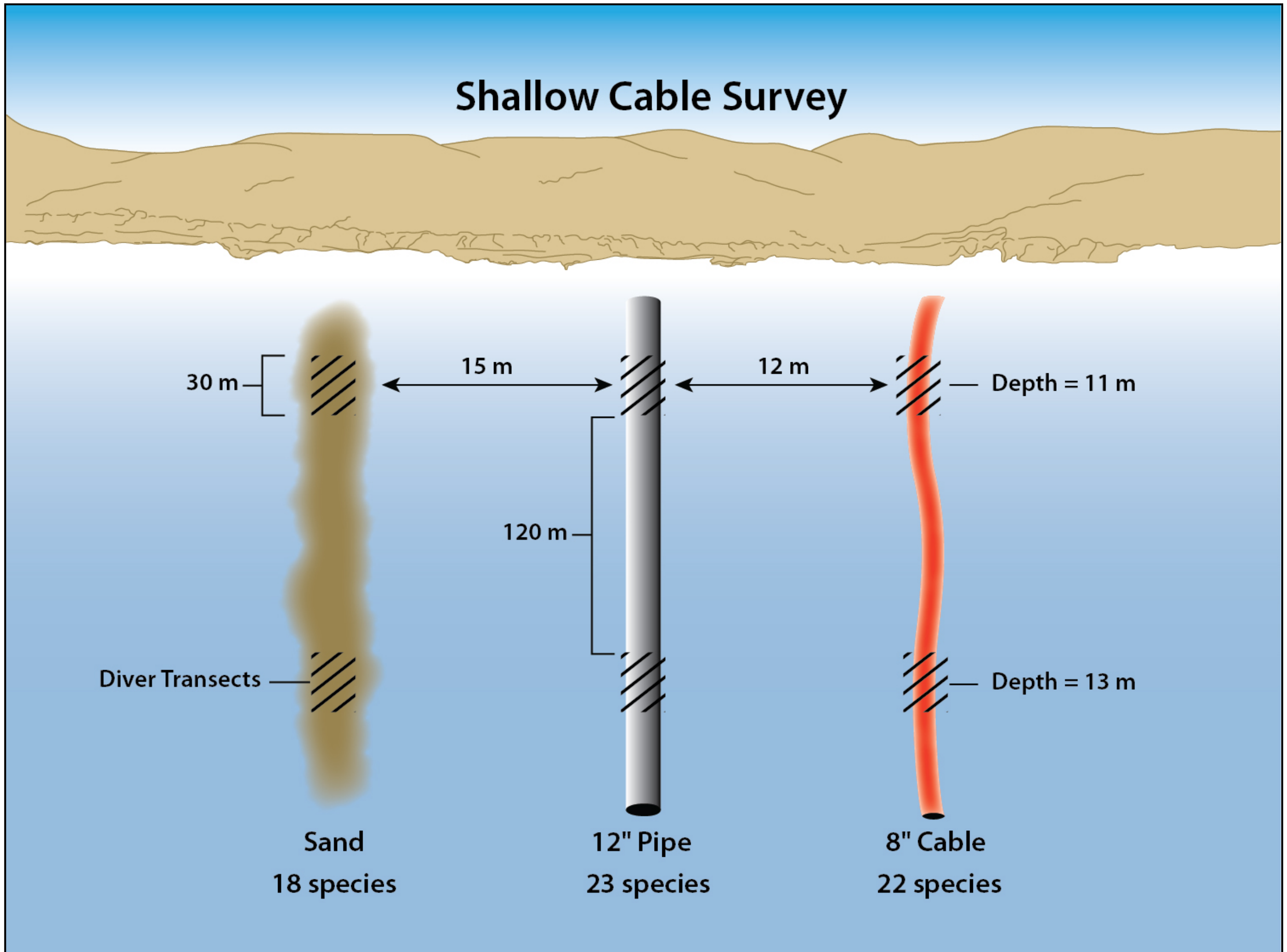
EE, Ph.D





EMF Study #2

Pipeline as Proxy for Unenergized Cable in Shallow Water Surveys

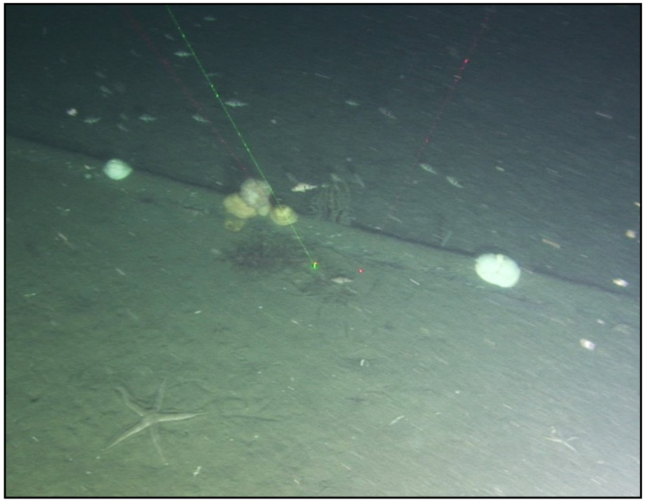


EMF Study #2

Some Findings from *in situ* Study

Mean EMF readings in µT

	SCUBA 11-13 m	Submersible 100-200 m
On Pipeline	0.5 µT	NA
On Cable	112 µT	109 µT
At ~0.5 m	2 µT	3 µT
At ~1 m	0.3 µT	0.2 µT
On Mud/Sand	0.0 µT	~0.05 µT



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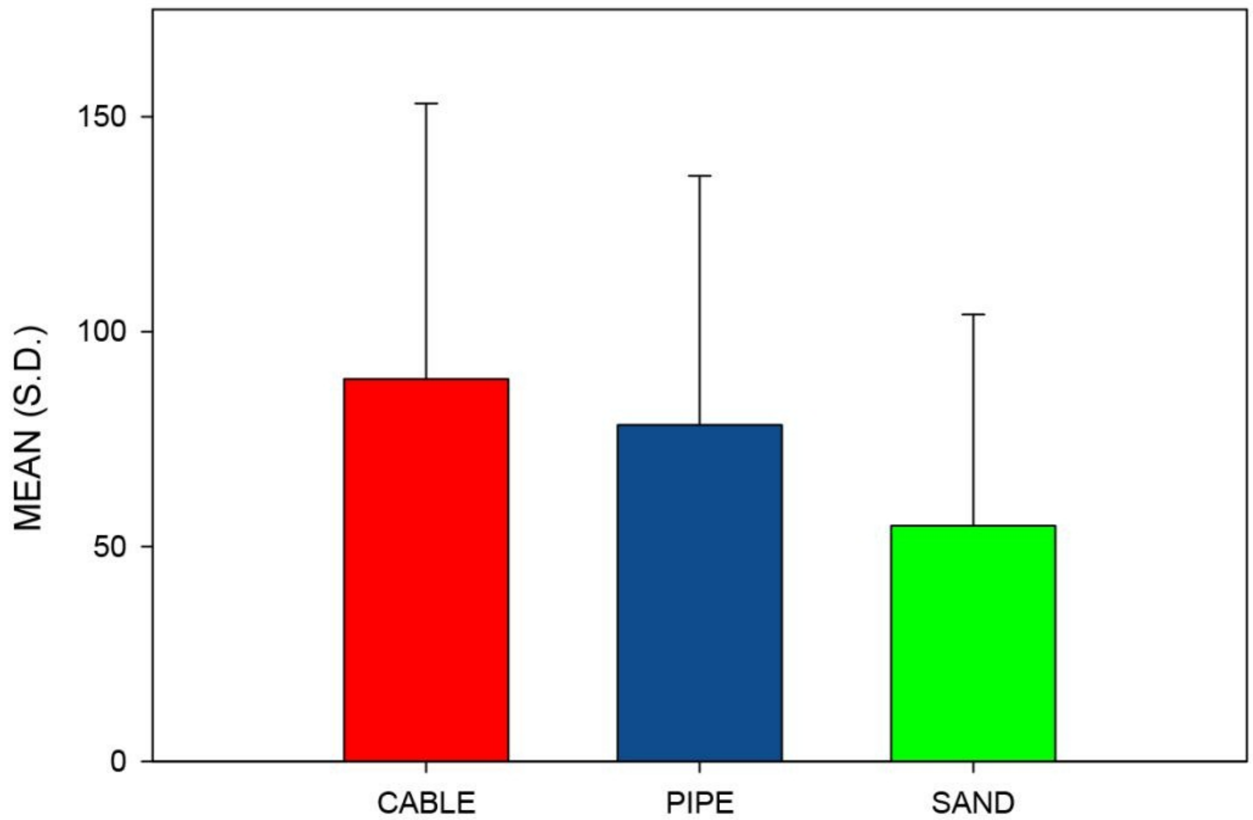
EMF Study #2

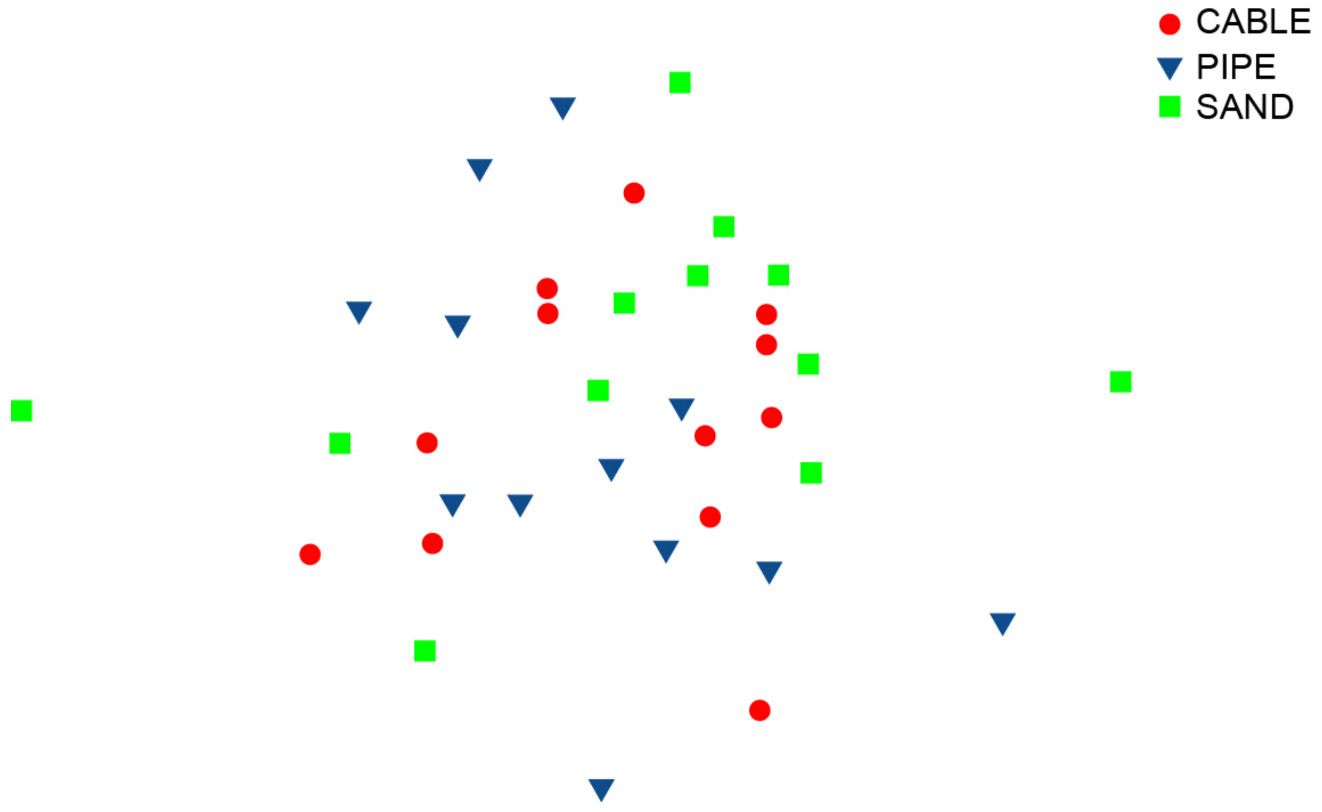
Some Findings from *in situ* Study – Shallow Water Depth

Average Number of Fishes Observed in Cable, Pipe, and Sand Habitats Per Survey Date from May through August 2012



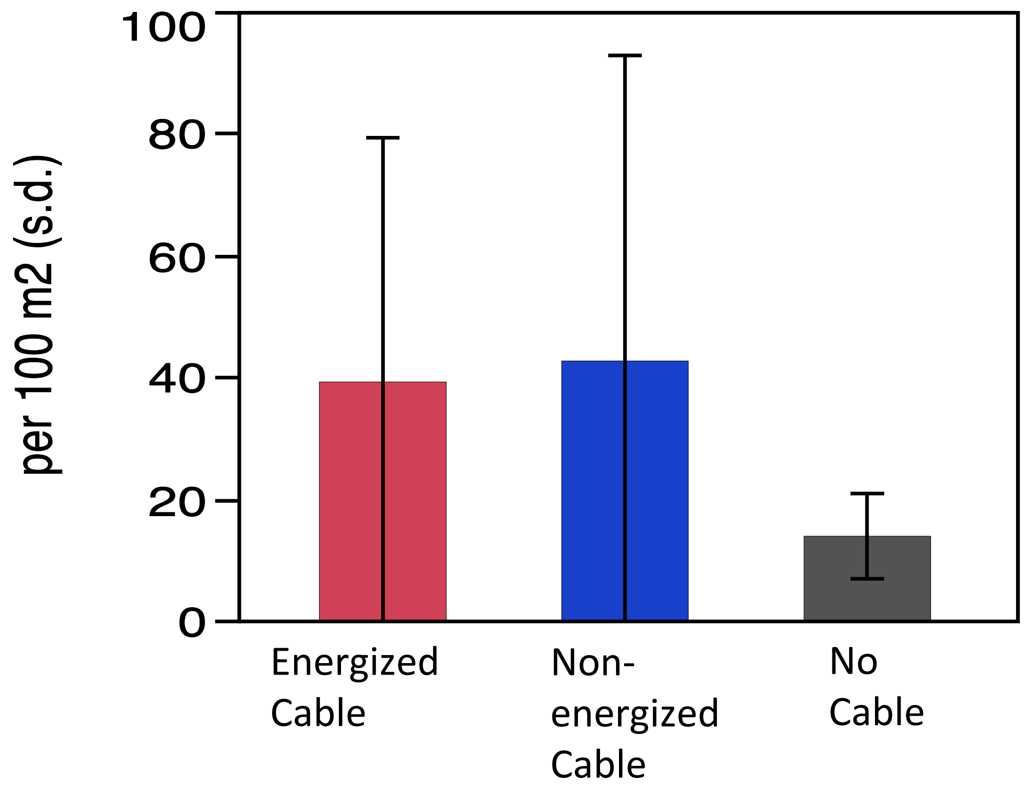
Multidimensional Scaling

All Fish Species – By Habitat
May through August 2012

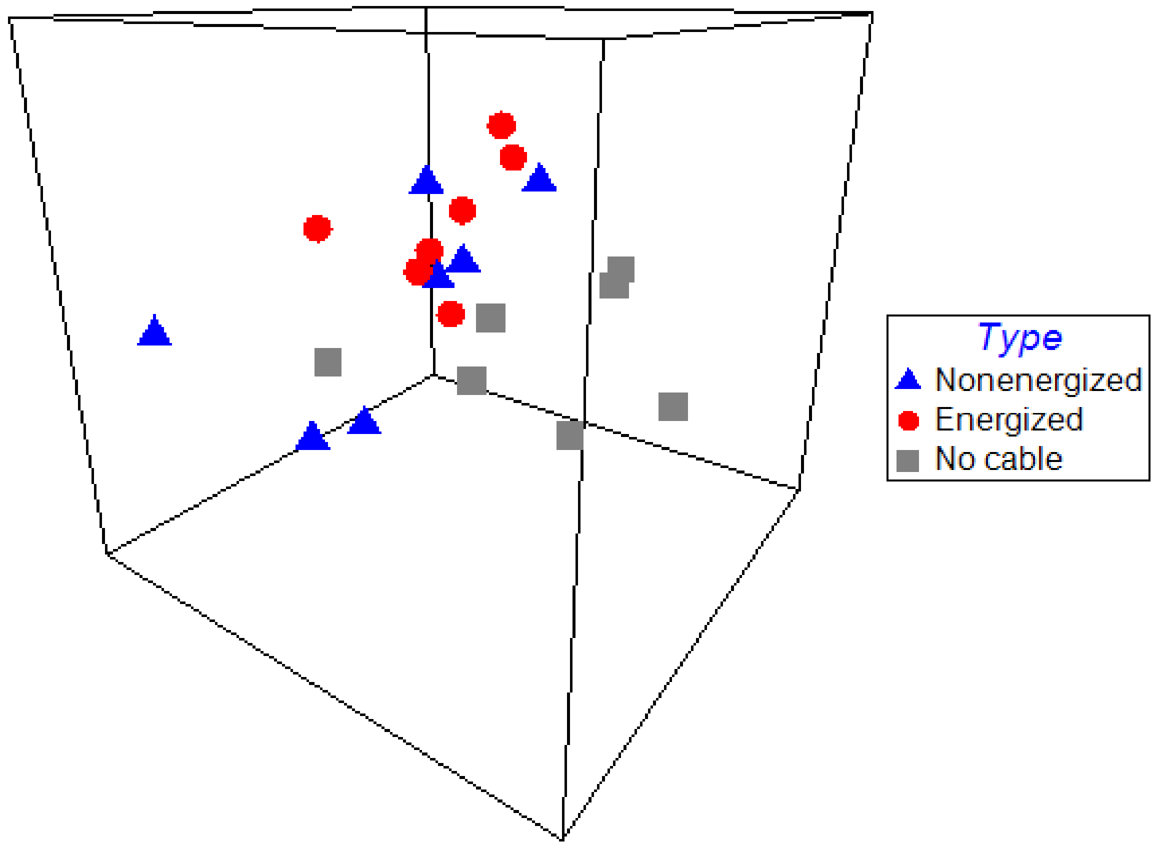


Some Findings from *in situ* Study – Deepwater Depth

Fish Density
24 Fish Species

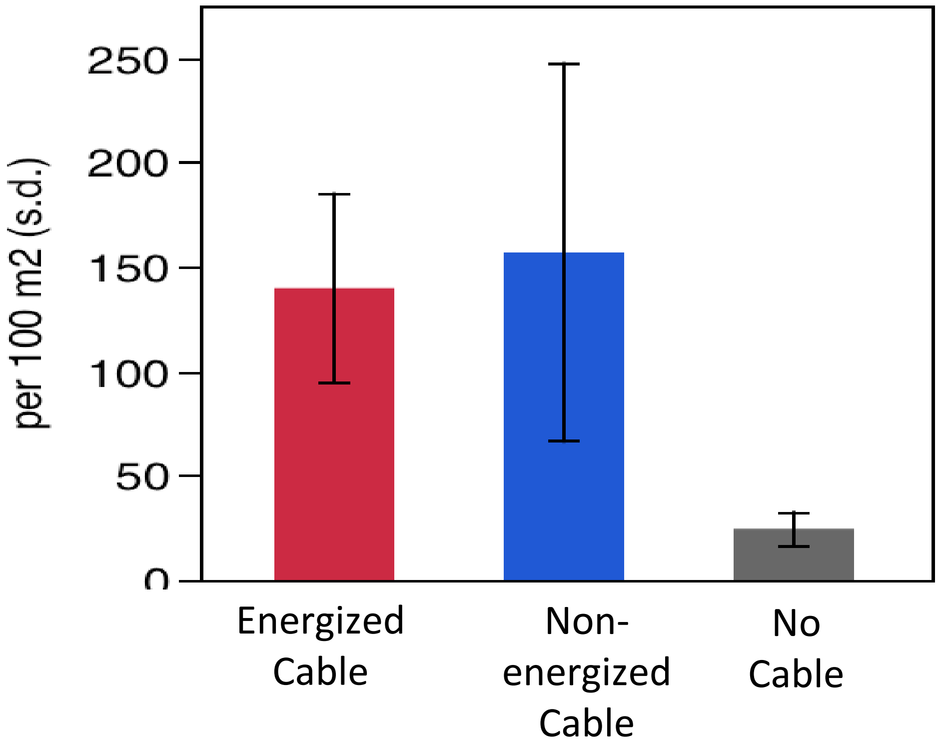


Multidimensional Scaling
All Fish Species – By Habitat
From 1-2 Years of Submersible Dives

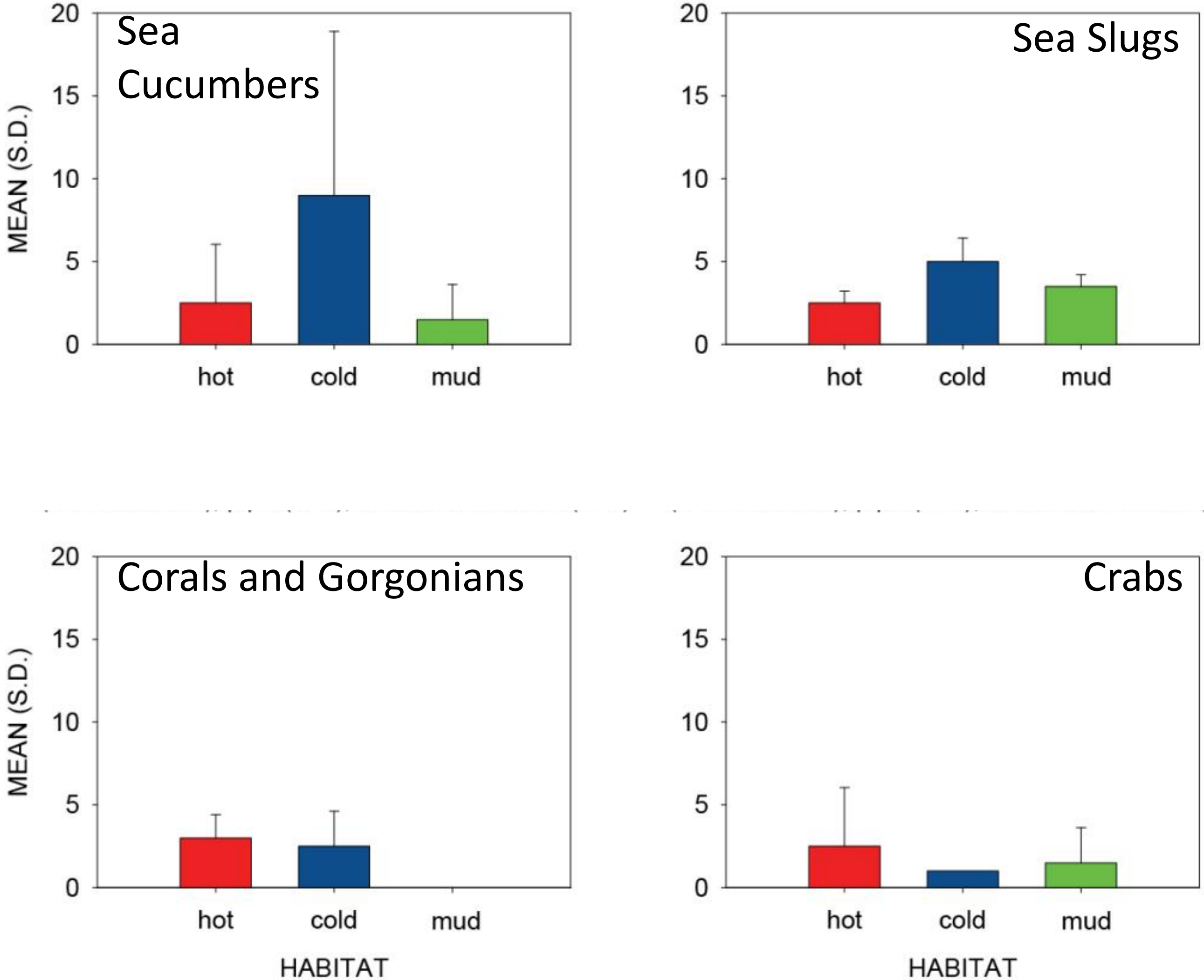


EMF Study #2

Invertebrate Density
16 Species



EMF Study #2



Sea Cucumbers
Sea Slugs
Corals and Gorgonians
Crabs
MEAN (S.D.)
MEAN (S.D.)
20
15
10
5
0
hot
cold
mud
HABITAT
HABITAT

Preliminary Findings from *in situ* Study

Unpublished Results from 1-2 Years of Surveys
Final Analyses (from All Years) will Clarify Conclusions

- Results suggest no response (attraction/repulsion) from fish or macroinvertebrates to EMF from a 35 kV AC *in situ* power transmission cable.
- Differences in invertebrate communities may be associated with sediment characteristics close to the cable and their patchy nature of distribution.
- Actual EMF measured on the cables and away from cable output closely fits the model results found in EMF Study #1.
- Apparent lack of response would indicate burial is not always essential for biological reasons.
- The results will be published in scientific journals and issued as a 2015 BOEM report.


BOEM-Supported Efforts
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Study #3

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EMF Study #3

Potential Impacts of Submarine Power Cables on Crab Harvest

Will EMF from a power cable affect commercial crab harvest?

Objectives:

- Determine if rock crab and dungeness crab will cross a power cable and be caught in commercial baited traps.
- Determine likely impact on harvest for assessment documents and planning.

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EMF Study #3

Potential Impacts of Submarine Power Cables on Crab Harvest

Will two crab species cross a power cable into a baited trap?

Methods:

- Use commercial crab fishermen and species.
- Determine the *in situ* EMF at AC and DC submarine cables.
- Expose rock crabs to 35 kV power cable with response choice in Santa Barbara Channel.
- Expose dungeness crabs to HVDC and/or AC power cables with response choice in Puget Sound.

Rock Crab Experimental Design for Santa Barbara Channel

Give Crabs a Choice to Decide if They will Cross a Power Cable in Response to a Baited Commercial Fishing Trap

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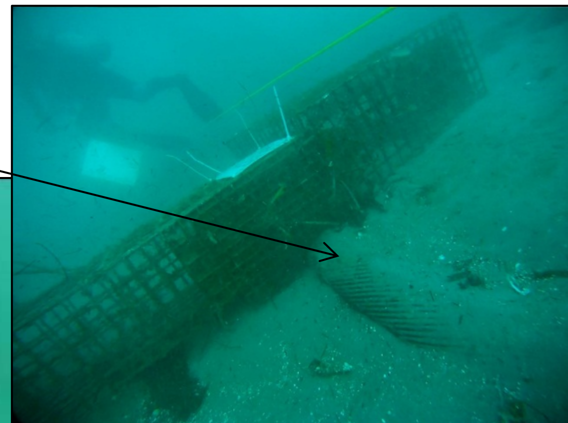
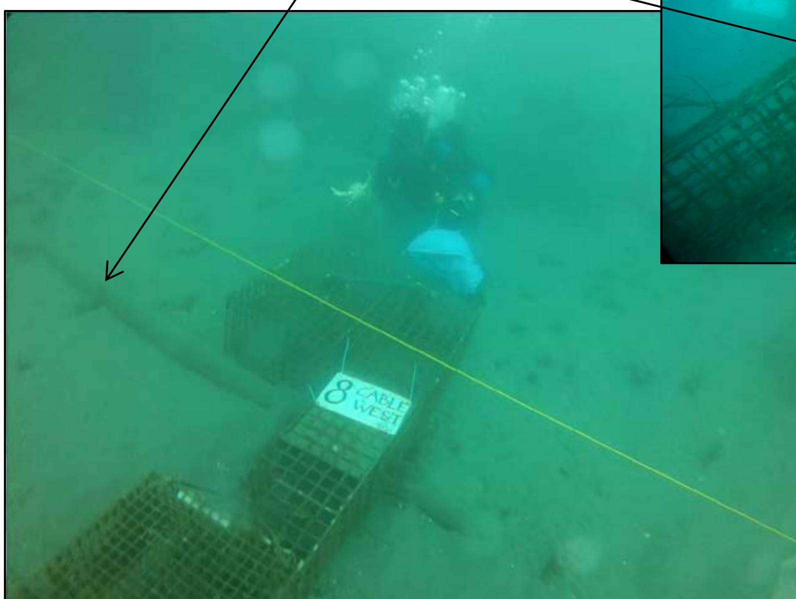
EMF Study #3

Rock Crab Experimental Design for Santa Barbara Channel

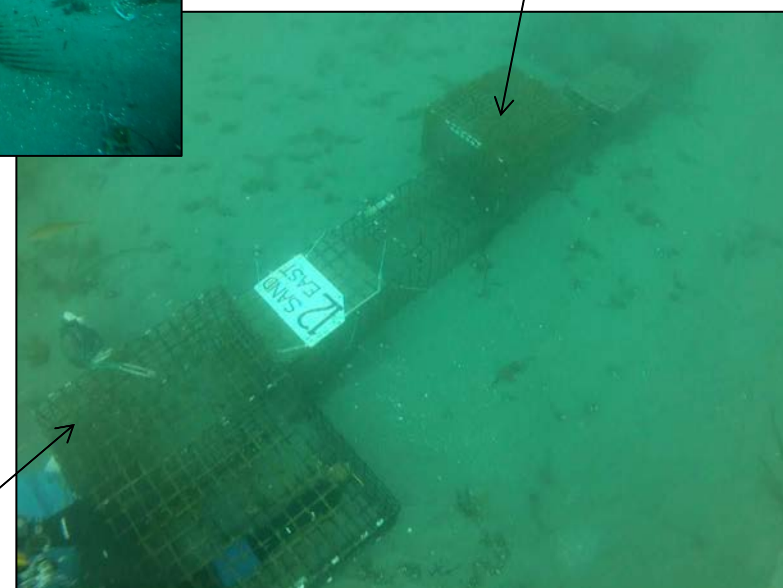
Give Crabs a Choice to Decide if They will Cross a Power Cable
in Response to a Baited Commercial Fishing Trap

Power Cable





Crab Introduction Chamber



Baited Trap

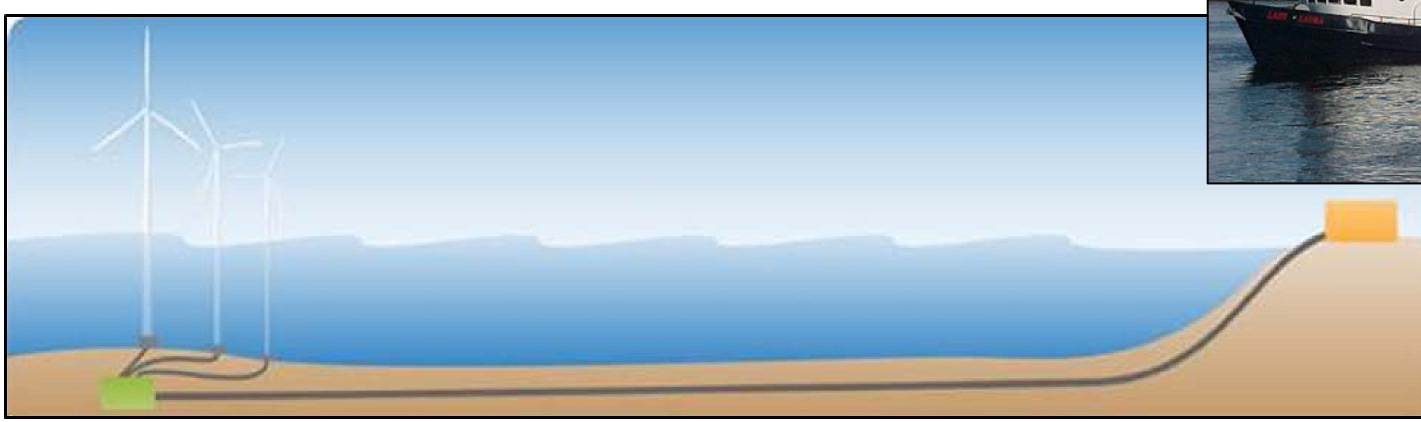
EMF Study #3

<u>Preliminary</u> Findings from *Potential Effects on Crab Harvest* Study

Unpublished Results from 332 Rock Crab Experiments

- Results suggest rock crabs will cross an unburied 35 kV AC power cable to enter baited commercial traps.

- The results will be published in scientific journals and issued as a 2017 BOEM report.



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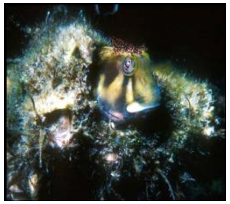

Our thanks to Nikola Tesla