Assessment of Potential Impact of Electromagnetic Fields from Undersea Cable on Migratory Fish Behavior

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Project Overview

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Assessment of Potential Impact of Electromagnetic Fields from Undersea Cable on Migratory Fish Behavior: Potential impacts from electromagnetic fields (EMF) from energized marine and hydrokinetic (MHK) devices or subsea cables on marine life is often raised as a concern during permitting processes. Since threatened and endangered species such as green sturgeon and chinook salmon migrate through the San Francisco Bay, this project explores relationship between EMF and fish orientation and normal migration movements.

The Challenge: No methods available to easily model magnetic fields (MF) from high voltage direct current (HVDC) undersea cables and no information on potential impacts on fish migration in the SF Bay environment.

Partners: Rob Kavet, Senior Technical Executive, Electric Power Research Institute (EPRI) (Retired); A. Peter Klimley, Adjunct Professor, University of California-Davis; Megan Wyman, Postdoctoral Researcher, University of California-Davis

Program Strategic Priorities

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Technology Maturity

- Test and demonstrate prototypes
- Develop cost effective approaches for installation, grid integration, operations and maintenance
- Conduct R&D for Innovative MHK systems & components
- Develop tools to optimize device and array performance and reliability
- Develop and apply quantitative metrics to advance MHK technologies

Deployment Barriers

- Identify potential improvements to regulatory processes and requirements
- **Support research focused on retiring or mitigating environmental risks and reducing costs**
- Build awareness of MHK technologies
- Ensure MHK interests are considered in coastal and marine planning processes
- Evaluate deployment infrastructure needs and possible approaches to bridge gaps

Market Development

- Support project demonstrations to reduce risk and build investor confidence
- Assess and communicate potential MHK market opportunities, including off-grid and non-electric
- Inform incentives and policy measures
- Develop, maintain and communicate our national strategy
- Support development of standards
- Expand MHK technical and research community

Crosscutting Approaches

- Enable access to testing facilities that help accelerate the pace of technology development
- Improve resource characterization to optimize technologies, reduce deployment risks and identify promising markets
- Exchange of data information and expertise

Project Strategic Alignment

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The Impacts

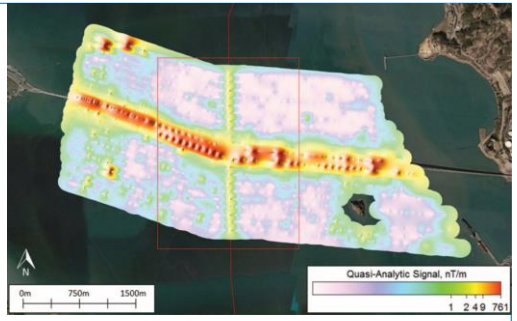
- Informs organizations planning deployment of planned HVDC undersea cables
- Methods to use for future MF work in underwater environments; Quantitative assessment of fish migration pre- and post-cable activation

Final products

- Demonstrated method for modeling the magnetic fields produced by the Trans Bay Cable (TBC)
- Compared magnetic fields produced by the TBC vs. bridge structures
- Used acoustic tracking to assess impact of TBC on Chinook salmon and green sturgeon: migration success, transit times/rates, and movement paths

Technical Approach

Magnetic Field Survey



Gradiometer survey transecting 4 areas in SF Bay to create a local MF map and a gradient map (change in MF)

Compared MF anomalies due to TBC (94 – 300 nT) vs. bridges (1142 – 4168 nT): average bridge anomalies approximately 8x - 26x higher than TBC anomalies (new information!)

Modeling Magnetic Field

Modeled magnetic field from TBC using Biot-Savart law and current load data

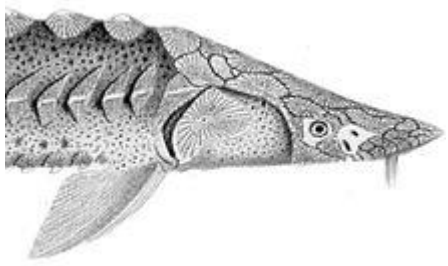
Compared modeled and empirically measured MF anomalies associated with the TBC: virtually identical (validates modeling methods for future studies)

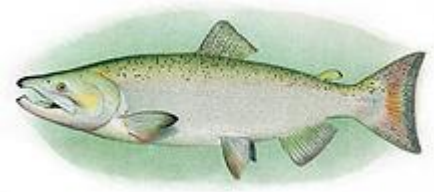
Assessing Fish Migration Behavior

Collected detections in San Francisco Bay of migrating fish implanted with acoustic transmitters

- Late-fall Chinook salmon smolts & adult green sturgeon
- Approach used a natural experiment: ongoing fish migratory studies conducted before and after cable activation

Examined migration success, transit times, transit rates, and movement patterns in relation to cable activation and other environmental parameters





Accomplishments and Progress

2014:

- Conducted detailed magnetometer survey at 4 locations within SF Bay
- Created local MF maps and MF gradient maps of survey locations
- Collected detections of Chinook salmon smolts and adult green sturgeon
- Modeled MF from TBC against empirical measures: nearly identical

2015:

- Created georeferenced based maps of MF, depth, TBC, acoustic monitors
- Collected environmental data in SF Bay (depth, temperature, currents, etc.)
- Submission of MF modeling methods to PlosOne (Kavet et al. 2016)

2016:

- Compared magnetic fields produced by the TBC vs. bridge structures
- Submission of bridge anomaly publication to PlosOne (in revision).

Major accomplishments: This project validated techniques for accurately modeling undersea EMF cables and found MF anomalies due to bridges were much larger than anomalies due to TBC. Successful fish migration of Chinook salmon smolts and adult green sturgeon in relation to TBC (and bridges) was not strongly impacted by TBC activation but transit times/rates were affected. Sturgeon took longer to exit the San Francisco Bay, but less time to migrate up through the Bay.

Project Plan & Schedule

- January 2014 – December 2015; Extended to June 2016

- Milestone delays
  - Unanticipated delays to collect and prepare environmental data, along with unplanned but necessary tests of tag detection range in San Francisco Bay (Delay from 3/2015 to 7/2015)
  - Difficult integration of environmental and fish datasets took longer than anticipated (delay from to 9/2015 to 12/2015)
  - Unanticipated complexity with green sturgeon analysis and technical difficulties (a computer crash) that erased some completed analysis (delay from 12/2015 to 6/2016)

- Go/No-Go FY 14: Summary of MF survey results, comparison of measured vs. modeled MF data, and fish detection data

Project Budget

Budget History*							
FY2014		FY2015		FY2016		TOTAL	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
$172.638k	$100.286k	$160.644k	$104.123k	$60.292k	$129.948k	$393.573k	$334.357k

- Variances from the project budget due to delays
- All funds have been expended
- No other additional funding sources were obtained

* Represents budget actuals

Research Integration & Collaboration

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Partners, Subcontractors, and Collaborators:

A. Peter Klimley, Adjunct Professor, University of California-Davis Department of Fish, Wildlife and Conservation Biology; Megan Wyman, Postdoctoral Researcher, University of California-Davis, Department of Fish, Wildlife & Conservation Biology

Communications and Technology Transfer:

- Wyman, M., Kavet, R. Klimley, P. Impacts of an underwater high voltage DC power cable on fish migration movements in the San Francisco Bay. 2016 Ocean Sciences Meeting. Feb 24-26, 2016.
- Kavet, R. Wyman, M., Klimley, P. Modeling Magnetic Fields from a DC Power Cable Buried Beneath San Francisco Bay Based on Empirical Measurements. PlosOne. February 26, 2016. Available at: http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0148543 ; 788 views since 2016.
- Klimley, P., Kavet, R., Wyman, M.. Chinook salmon and green sturgeon migrate through San Francisco Estuary despite large distortions in the local magnetic field produced by bridges. PlosOne (*in revision*)

Next Steps and Future Research

FY17/Current research: N/A

Proposed future research:

- Fish tracking studies with transmitters that characterize the swimming behavior of fish as they pass over the cable and a 3-axis gradiometer to measure the strength of the MF from the cable experienced by fish
- Ideally, these fish movements would be tracked using arrays which allow for spatial triangulation of fish location in relation to empirically measured EMF intensities
- Studies which examine behavioral changes when a high voltage cable is experimentally activated vs. not activated

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