Modeling Electric Fields Produced by Weakly Electric Fish

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Introduction

- Weakly electric fish use an 'electrosense' to detect and analyze their surroundings
- *Apteronotus leptorhynchus* (Brown Ghost Knifefish) modeled
- Electric fields generated from electric organ (EO)
- Need to more accurately determine electric distribution from EO to more precisely model interaction of fish with surroundings
- Experiments have been done to determine the electric potential distribution and is used for comparison

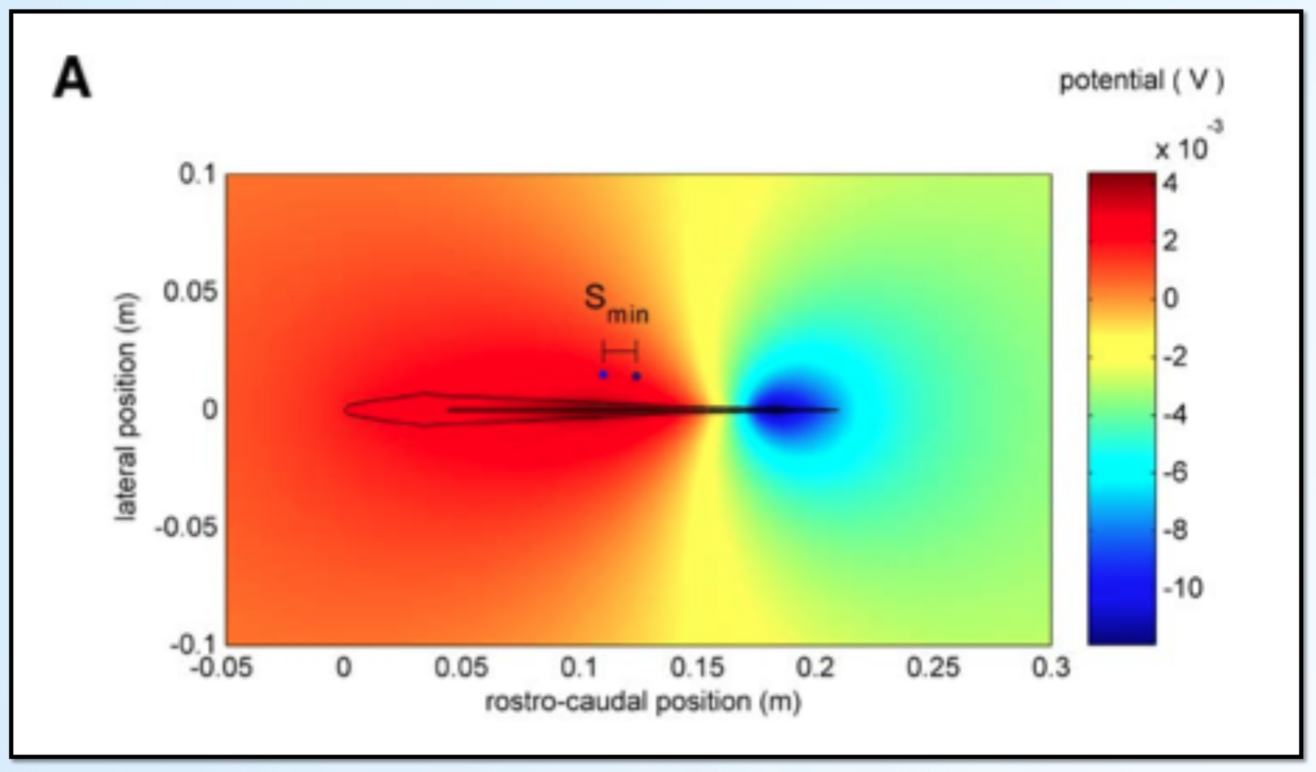

Figure 1. Electric field potential generated from weakly electric fish. Two objects are present but have little effect on the potential distribution.

Background

- Weakly electric fish refers to fish whose electric output is less than 1 Volt
- Small range of electro-location
- Fish create an oscillatory dipole-like distribution from EO
- Receptors on the skin sense when objects perturb the self-generated electric field due to varying electric properties and thereby create an electric image
- Inverse problem: Given the electric field distribution we need to determine the source function from the EO
- With more accurate model of EO, effect of surroundings and interactions between fish on electric image can be better understood

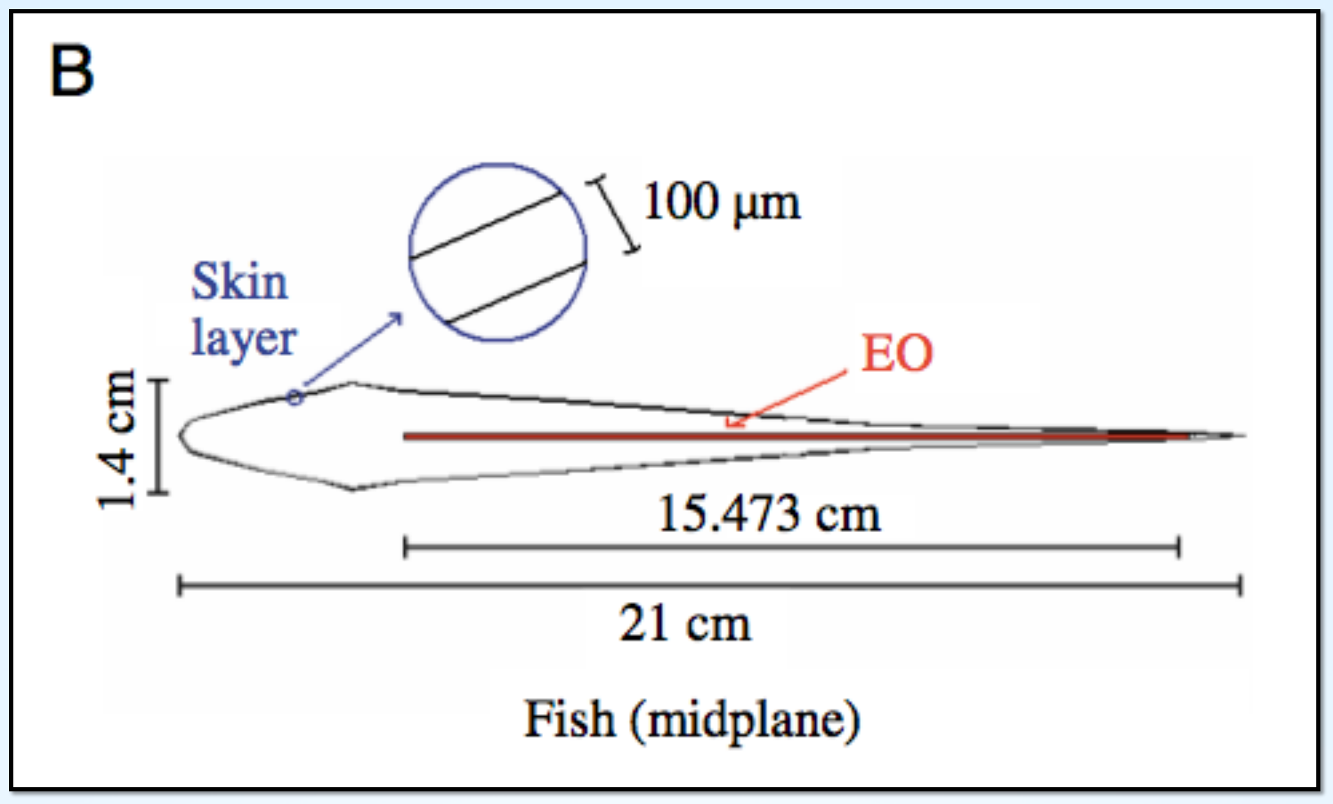

Figure 2. Fish as modeled in the program. Morphologically accurate with skin, body, and electric organ. The fish is placed in a 2-dimensional aquarium with a ground in the upper corner.

COMSOL Multiphysics Model

- Uses finite element method (FEM) COMSOL Multiphysics Software
- Program version assumes uniformity in z-direction but with discretized EO
- Body is represented as morphologically accurate with skin, body container, and EO
- Previous models are in 2D, new version exists to extend model to 3D
- Original approximation used two Gaussian functions
- Software used to solve Poisson's equations for the electrostatic boundary value problem
- EO discretized and each section assigned current density values
- Number of discretized sections and current density profile modified from Kelly et al. paper

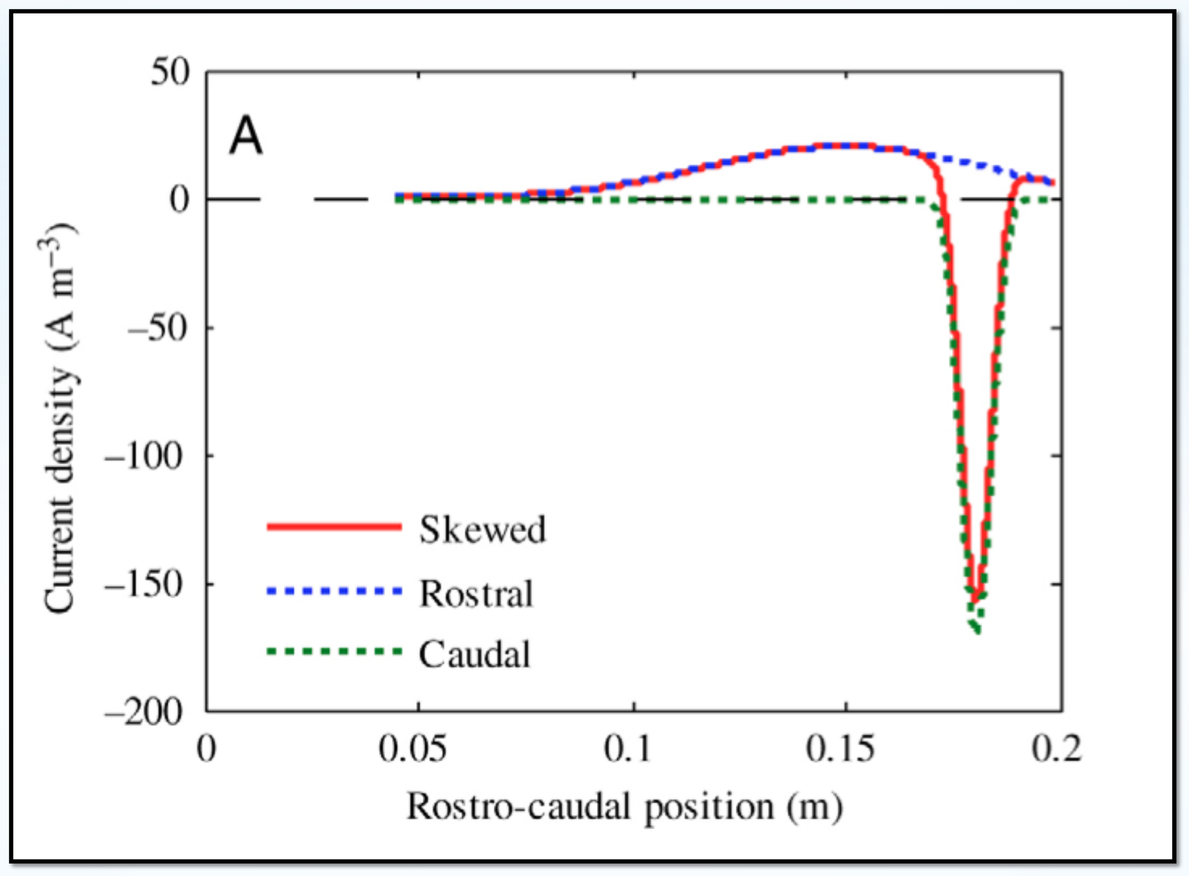

Figure 3. Previous model of current density distribution in EO. The skewed profile is the combination of the two Gaussian curves.

Results

- EO divided into 50 sections and current density values applied
- Artifact electric sources were removed (eg extra electrodes)
- Lack of dipole-like distribution
- Different current density profiles applied to the discretized EO

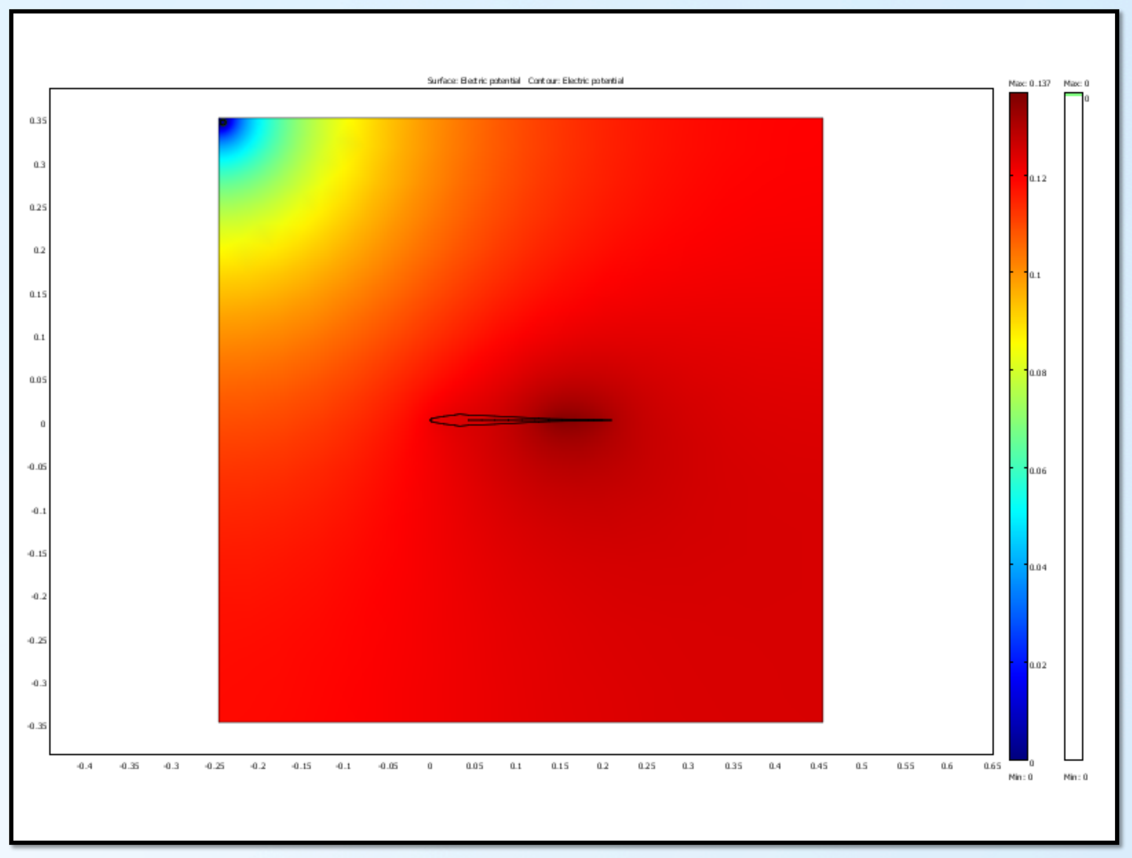

Figure 4. Electric field potential generated from weakly electric fish from the version of the program used. Lack of dipole-like distribution evident. Electric organ divided into 50 components.

Further Research

- Evaluation of program needed to replicate previous results
- Possibly revert to previous version of program and modify EO on it
- Once dipole-like distribution established, electric image on surface of body can be determined when two fish interact
- Social interactions between fish can be investigated

Acknowledgments

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References

Figure 1 and 2 taken from D Babineau, JE Lewis, A Longtin (2007) *Spatial Acuity and Prey Detection in Weakly Electric Fish.* PLoS Computational Biology 3(3): e38

Figure 2 and 3 taken from D Babineau, A Longtin, JE Lewis (2006) *Modeling the Electric Field of Weakly Electric Fish.* Journal of Experimental Biology 209, 3636-3651

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