Bright Vibrating Screens: Increasing the Detectability of Fish Screens

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In California water is diverted from rivers and the ocean to supply agricultural, residential, and electrical power needs.

Photograph by Doug Craft from the Bureau of Reclamation's website.

How do fish detect screens placed in front of water diversions?

Vision

Chemoreception

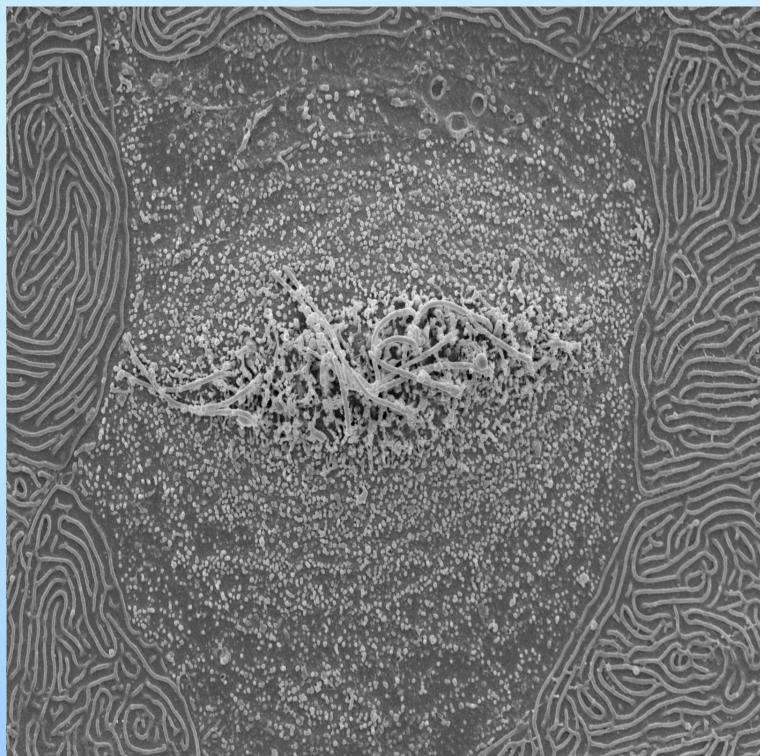
Tactile responses

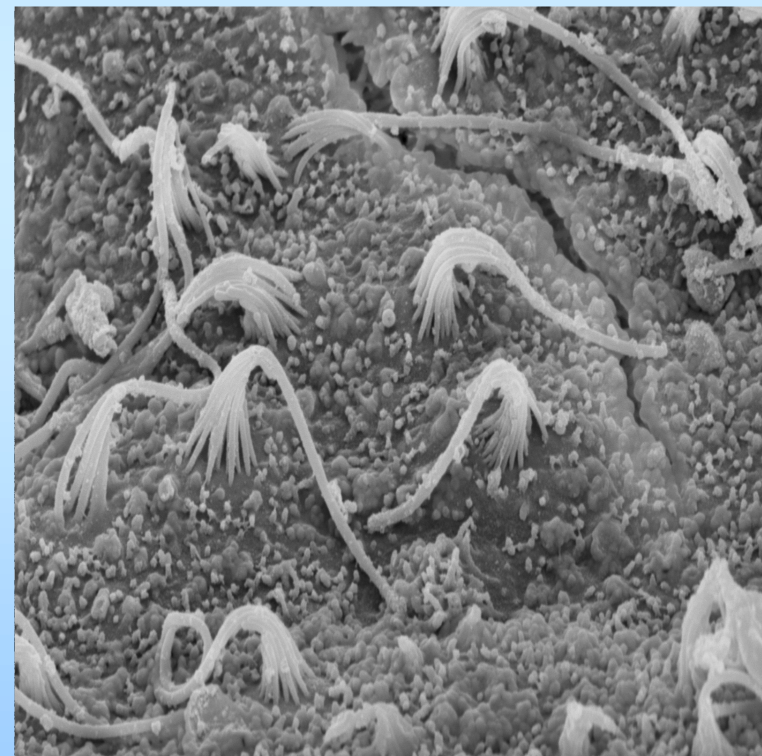
Far-field Sound (detected by the fish's inner ear)

Near-field Sound (detected by the fish’s lateral line system)

The Lateral Line System

- All fish have lateral line systems.
- The lateral line system is more extensive in some species of fish than others.
- It allows fish to detect water flows and vibrations.
- Neuromasts are composed of many hair cells which are sensitive to vibrations in one direction.





Scanning Electron Microscope Images of a Neuromast

Superficial and Canal Neuromasts

Superficial neuromasts:

Located on the epidermis and function best in still water.

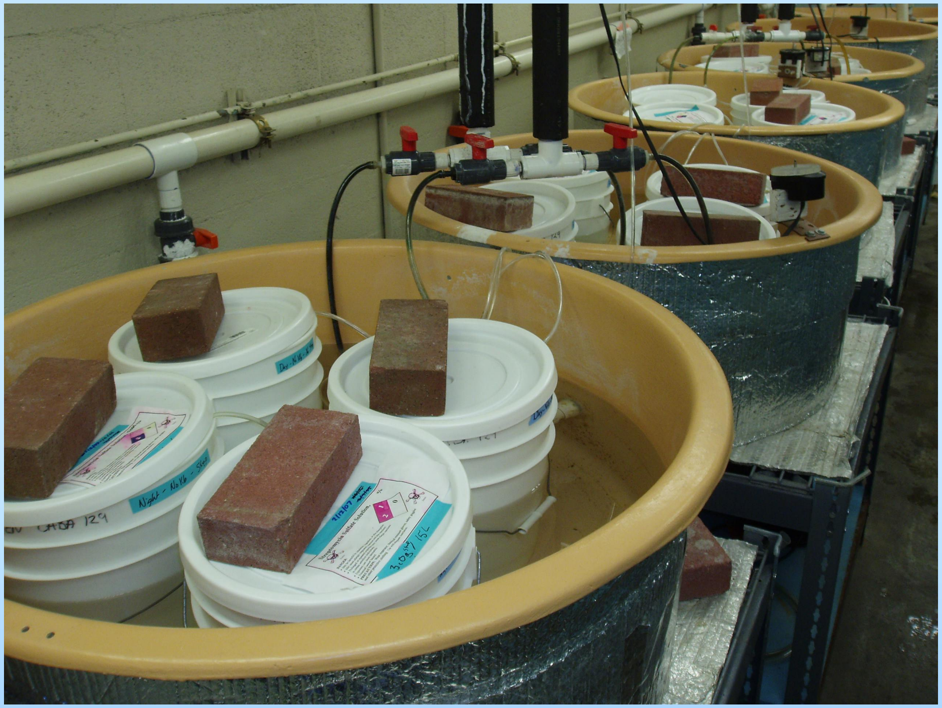
Commonly detect low frequency vibrations (1 - 30 Hz).

Canal neuromasts:

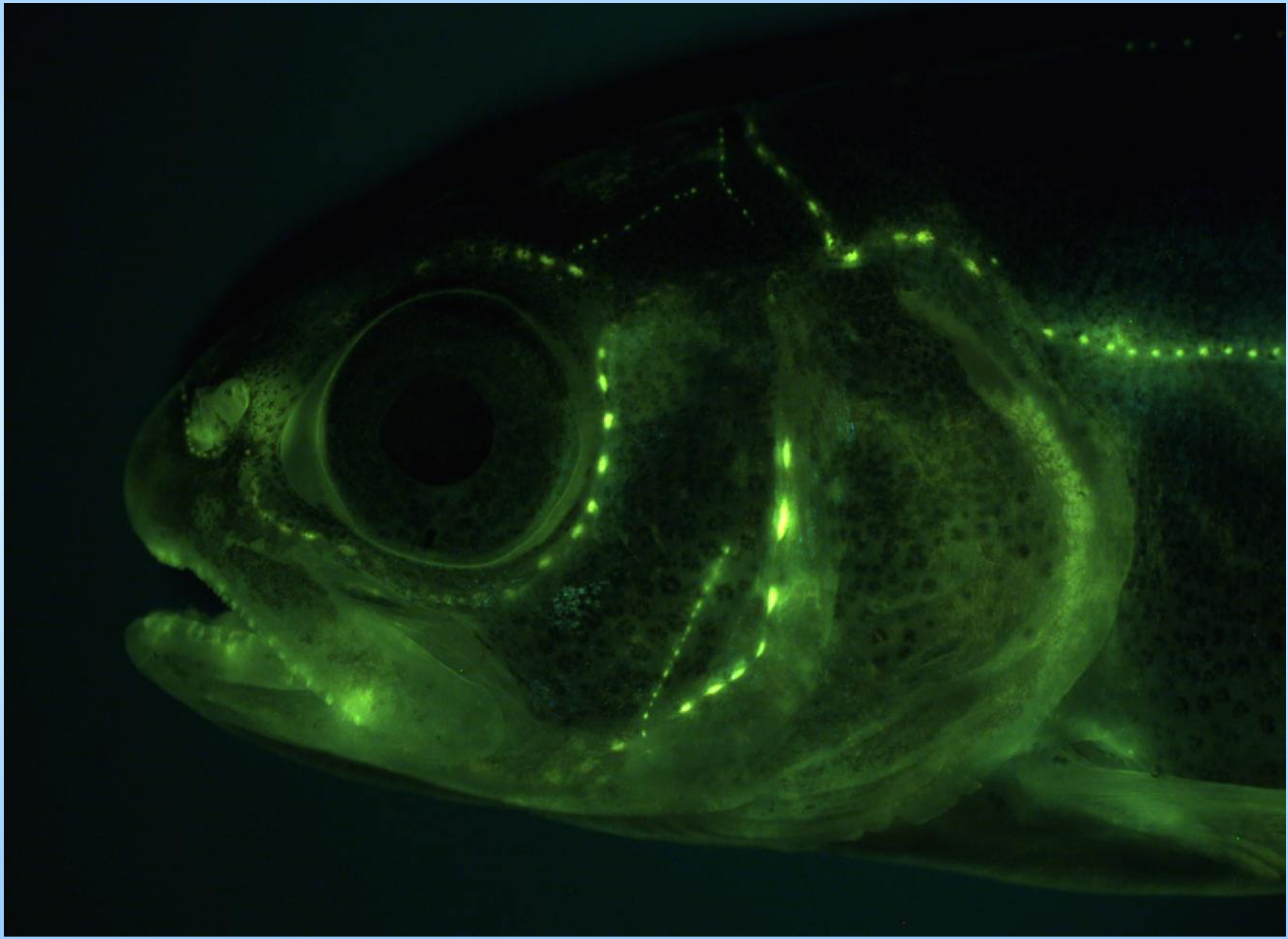
Located in canals running through the fish's scales or bones they are less impaired by moving water.

Commonly detect higher frequency vibrations (30 - 200 Hz).

Streptomycin sulfate will kill all of the fish's neuromasts at high doses.

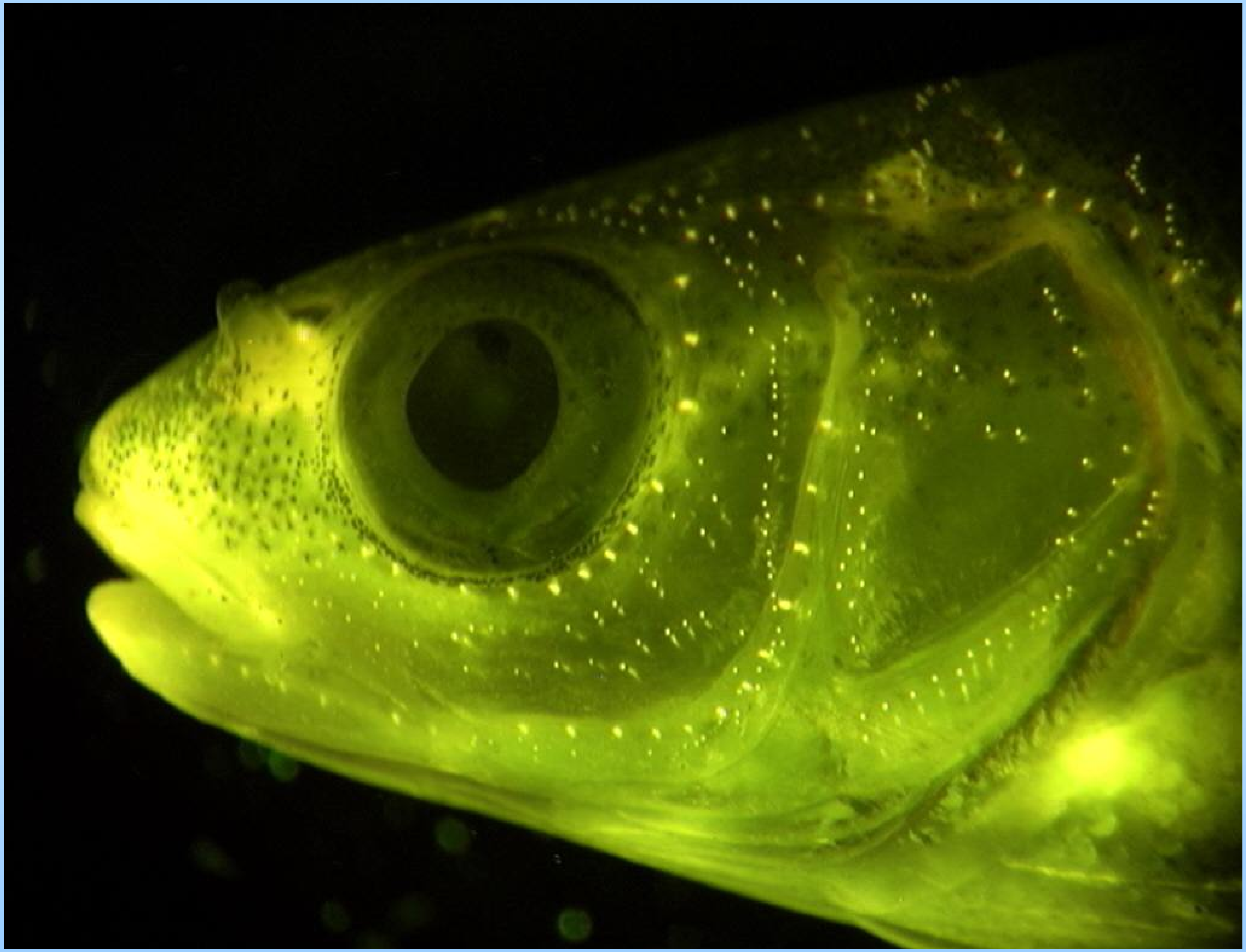


Juvenile steelhead treated with DASPEI stain and viewed under a fluorescent microscope



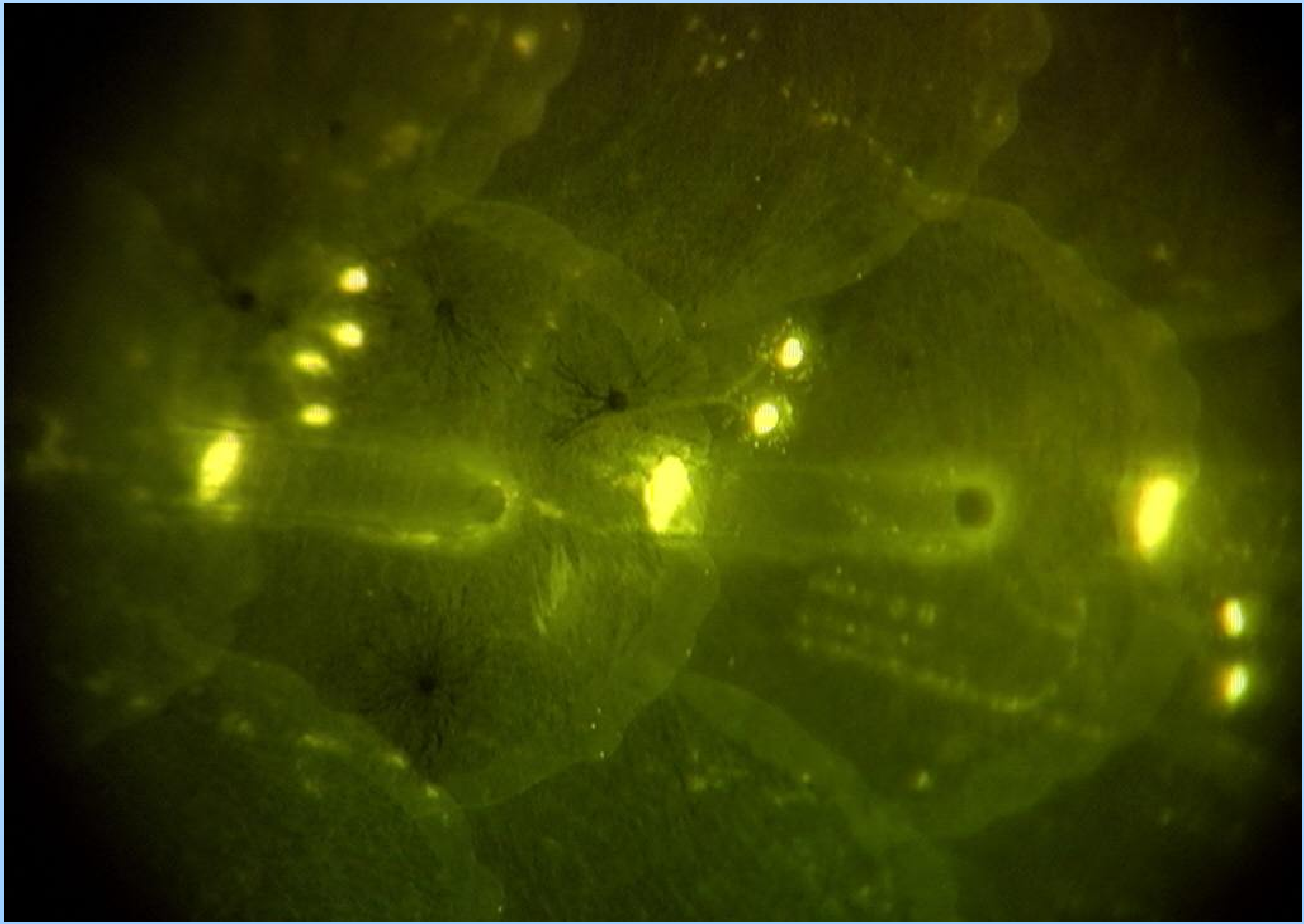
Juvenile splittail stained with DASPEI

(a native California cyprinid)



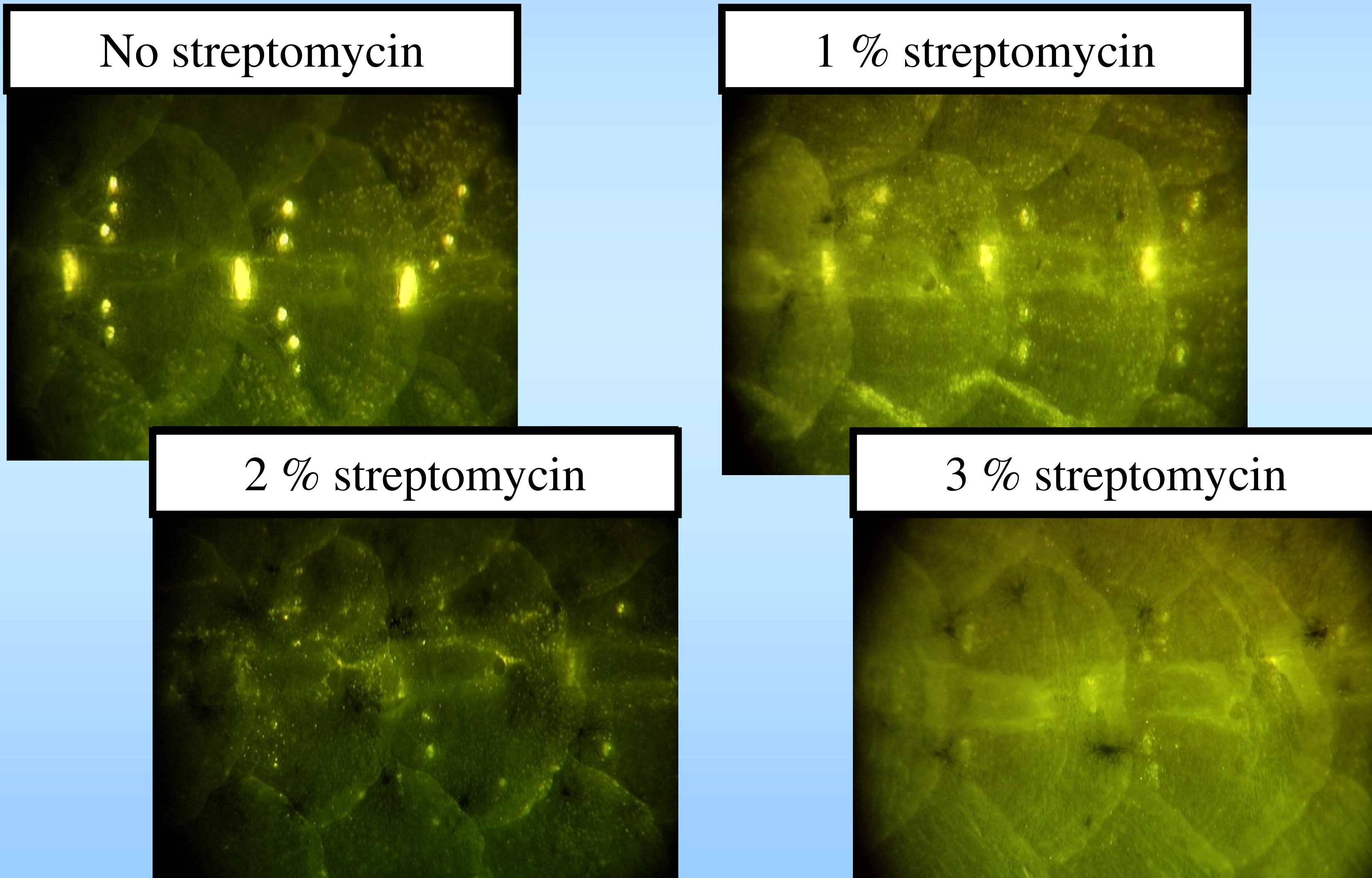
Lateral line trunk neuromasts of splittail

stained with DASPEI, 5X magnification.



Blocking Mechanoreception:

Splittail trunk lateral line neuromasts stained with DASPEI following 24h of streptomycin exposure.



Blocking Vision

Testing the fish's ability to avoid screens in the dark can test the importance of vision.

Infrared video equipment can be used to record the fish's swimming behaviors.

Can vibrating screens repel fish?

Some fish show avoidance responses to vibrations at particular (low) frequencies.

Attaching industrial pneumatic vibrators to fish screens allows them to project strong near-field vibrations and potentially deter fish from contacting the screen.

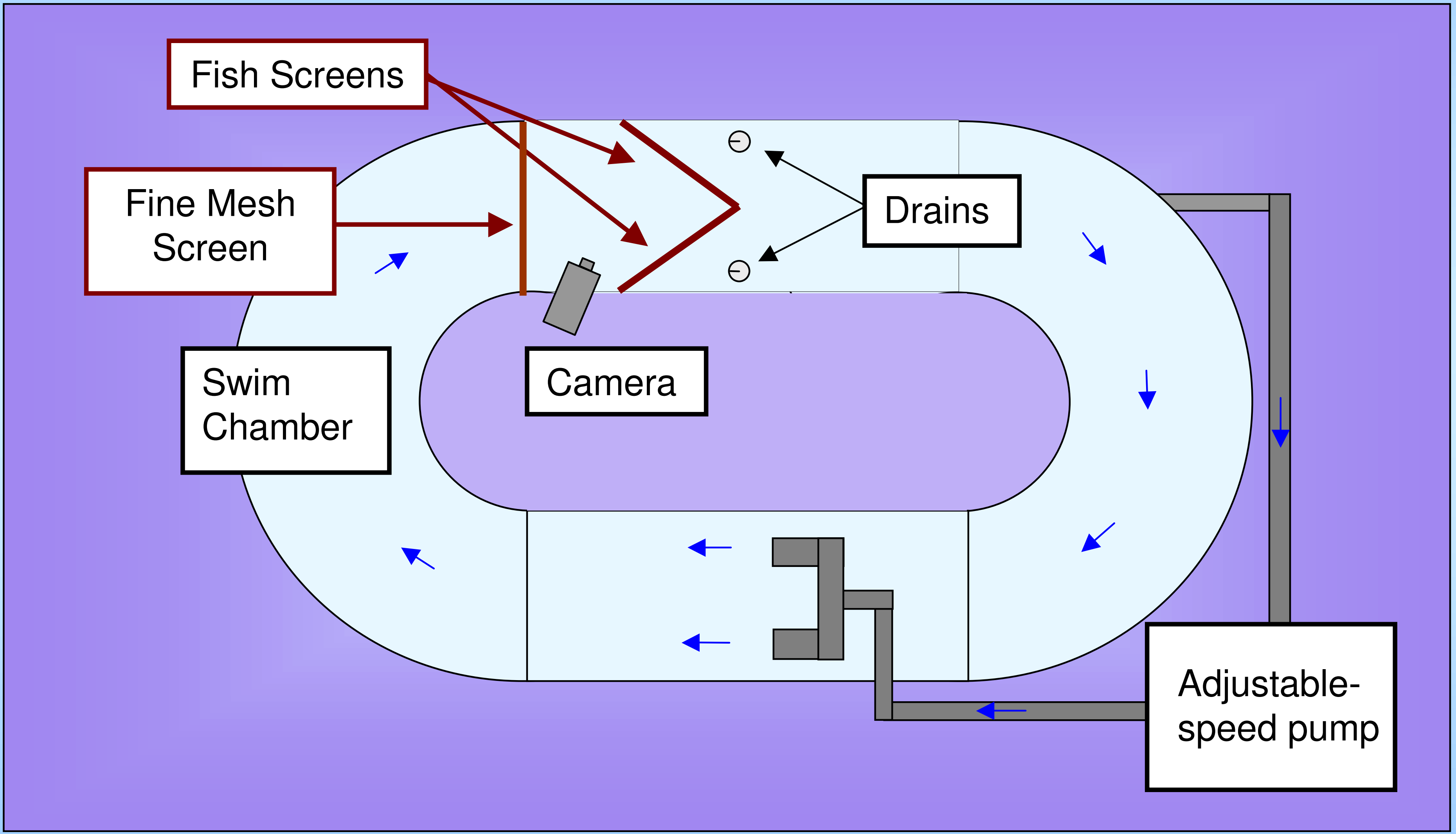
Industrial Vibrators:

Houston BV 150

Netter Vibration 150

B.E.S. INC. FP-35-L

Swimming Chamber Diagram



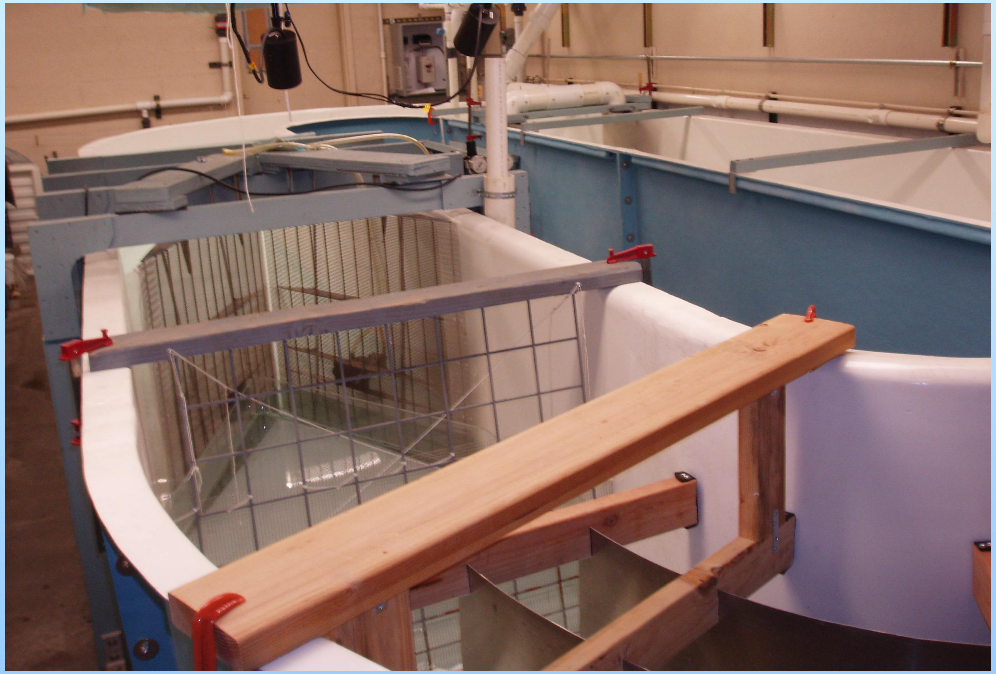
Swimming Chamber Dimensions

Oval chamber dimensions = 8.5m long X 3.5m wide, with a 1m channel

Water depth = 30 cm; Water velocity = 50 cm/sec

Fish were confined to a 1.5 m section of the chamber, by wedge-wire screens at the back and a fine mesh screen at the front.

A plexiglas view plate was placed on the surface of the water, allowing clear observations.



Factors tested on juvenile steelhead and splittail

All combinations of the three factors were tested per day and randomized within the day and night.

A new 6cm ± 2cm fish was used in each trial, thus 8 fish were used per day.

The fish were given one hour to acclimate to the chamber.

The trials were 15 min long.

Daytime Full spectrum illumination	
No Streptomycin	No Vibration
Streptomycin	No Vibration
No Streptomycin	Vibration
Streptomycin	Vibration

Nighttime Infrared illumination	
No Streptomycin	No Vibration
Streptomycin	No Vibration
No Streptomycin	Vibration
Streptomycin	Vibration

Both juvenile steelhead and splittail contacted the screens more frequently at night than day.

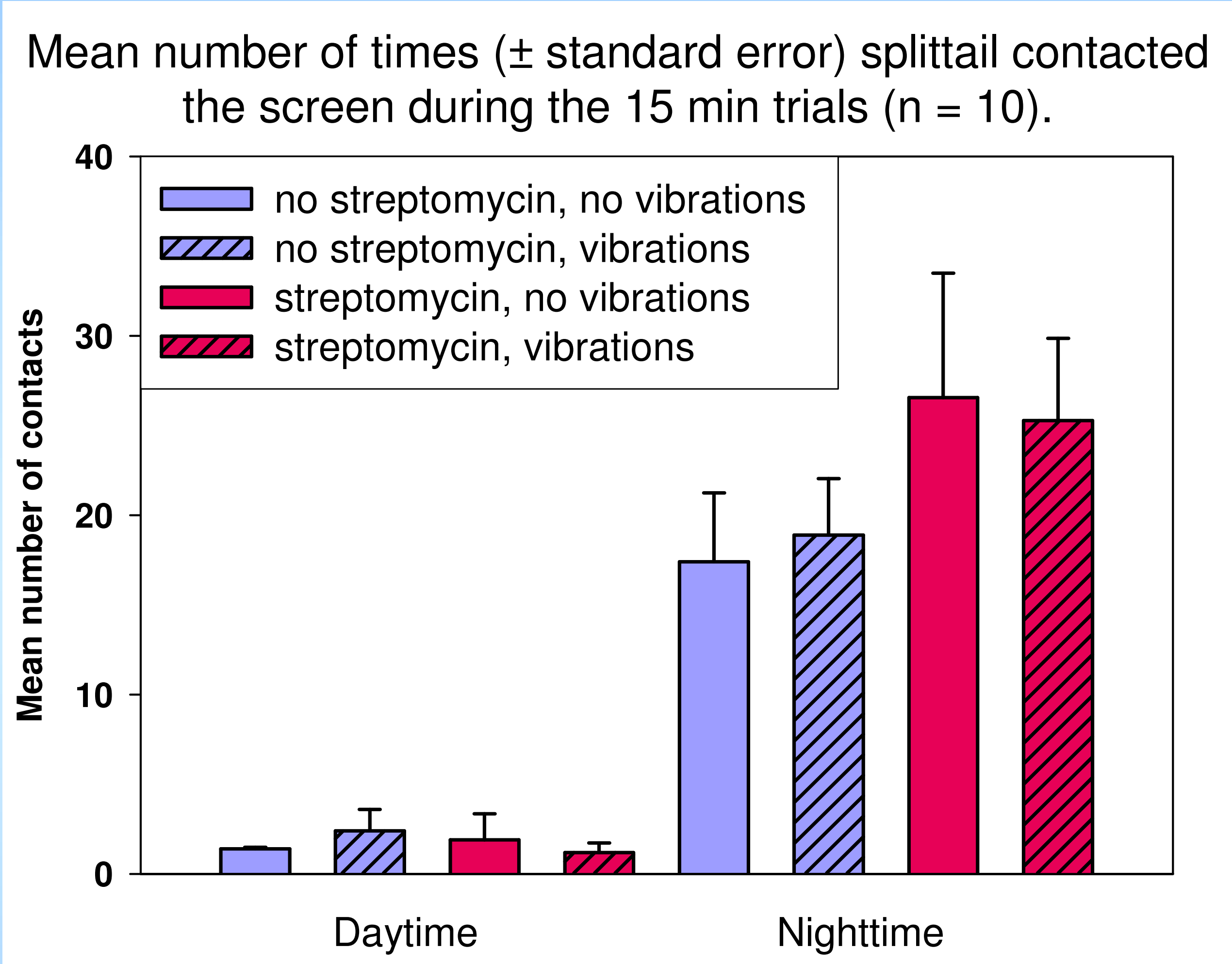
Mean number of times the fish contacted the screen in 15 min (± standard error).

	Steelhead (n = 32)	Splittail (n = 40)
Daytime	3.9 (± 0.7)	1.7 (± 0.3)
Nighttime	7.7 (± 1.4)	22 (± 3.5)

Why were the contact amounts different between the species?

- The streptomycin dose for the steelhead was too low and had no effect.

The splittail data was statistically tested with a three-way multivariate test fitted to a Poisson distribution.



The Nighttime mean number of contacts (22) is significantly ($P<0.001$) different from Daytime mean contacts (1.7).

During Nighttime the mean number of contacts in the streptomycin treated fish (25.9) is significantly ($P<0.001$) different from the non-treated fish (18.2).

"Permanent" Impingement Results

The splittail were more likely to become permanently impinged on the screens at night after being treated by streptomycin.

Impingement rate:	**(N=20)**
<u>Non-Treated Fish</u>	<u>Streptomycin Treated Fish</u>
15%	60%

Significantly different using Fisher Exact Test ($p = 0.008$).

Factors tested on yearling steelhead and splittail

Vibrations, strobe lights and streptomycin treatments were tested on yearling steelhead and splittail during the night.

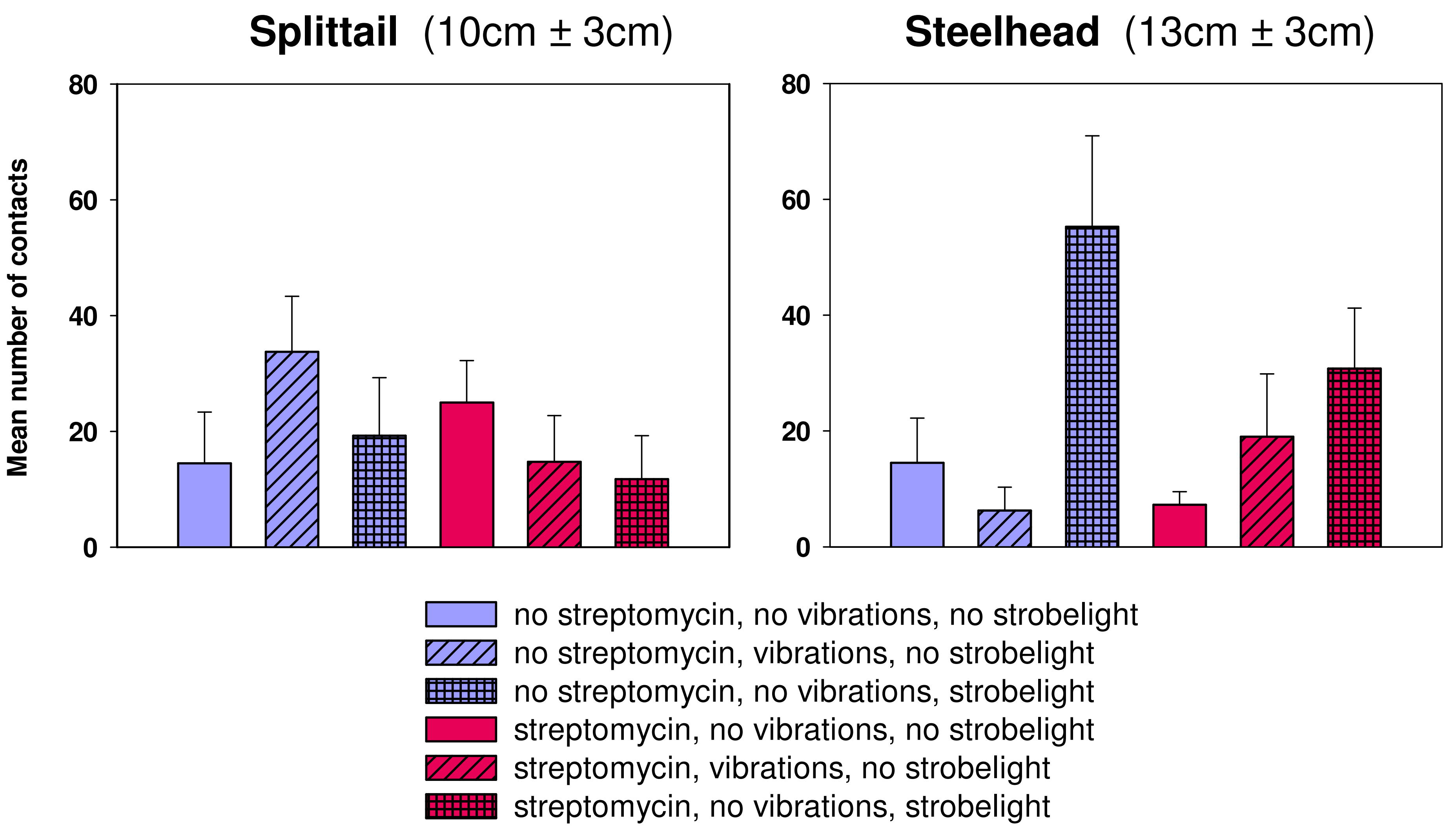
The vibrator used produced a lower frequency vibrations of 35 Hz

A Stroboscope was used to produce a precise flash rate of 300 flashes/min.

Nighttime Infrared illumination	
No Streptomycin	No Vibration
No Streptomycin	Vibration
No Streptomycin	Strobe light
Streptomycin	No Vibration
Streptomycin	Vibration
Streptomycin	Strobe light

Monarch Stroboscope

Mean number of times (± standard error) yearling fish contacted the screen during the 15 min trials (n = 4).



“Permanent” Impingement Results

Comparison of streptomycin treated fish vs. non-treated fish during night experiments

Splittail Impingement Rate: **(N=12)**

Non-Treated Fish	Streptomycin Treated Fish
42%	75%

Steelhead Impingement Rate: **(N=12)**

Non-Treated Fish	Streptomycin Treated Fish
0%	8%

No significant differences were found between the treatment groups for either species using Fisher Exact Test (p = 0.008).

Splittail P=0.214 Steelhead P=1.00

Example of splittail swimming during daytime

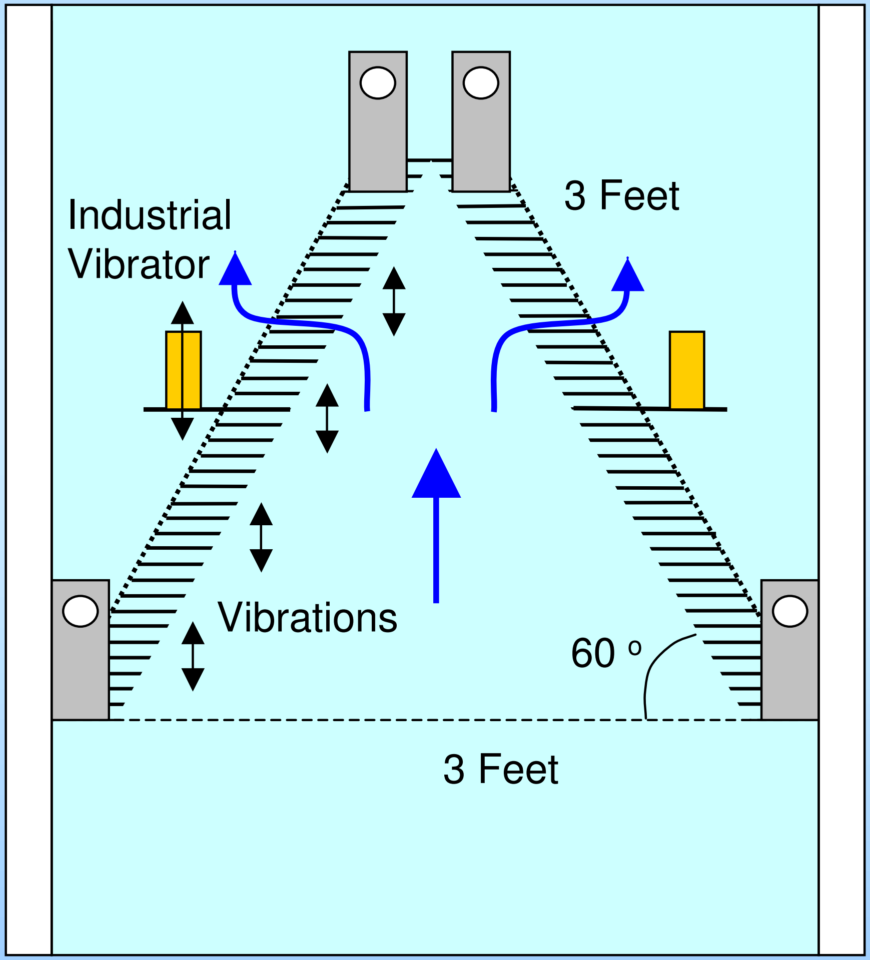
Example of splittail swimming during nighttime

Findings

- Juvenile splittail and steelhead contact fish screens more frequently during the night than during the day.
- Juvenile splittail use their lateral line system to avoid contact and impingement with fish screens during the night, but yearling fish show less dependence.
- Vibrating the screen at 50 or 35 Hz does not affect the swimming performance of steelhead or splittail.
- Flashing lights added near screens appear to startle steelhead and possibly increase their contact rate.

Future Experiments

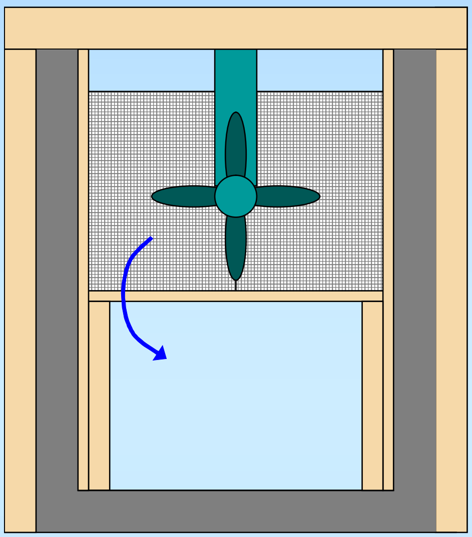
Overhead Diagram of Louvers Suspended in the Swimming Chamber



Future Experiments

Research on Marine Species at the UC Davis Bodega Marine Laboratory

End view

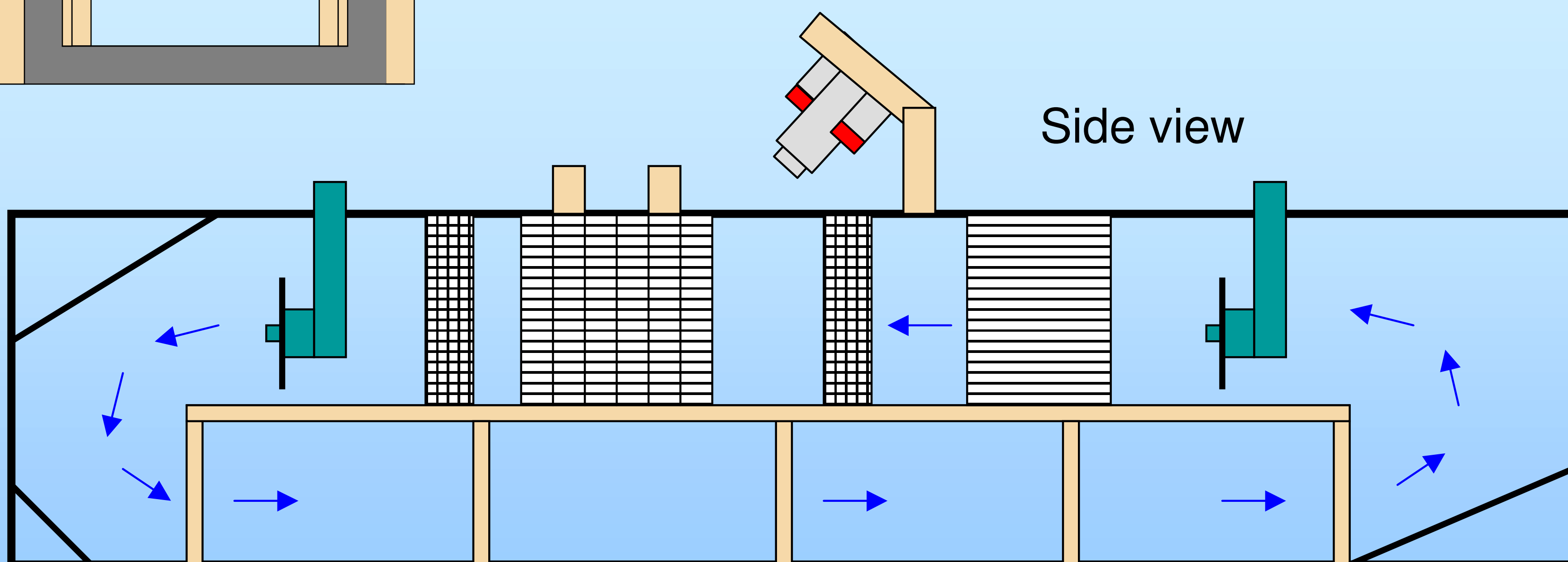


Jacksmelt - *Atherinopsis californiensis*

Photograph from The Aquarium at the Bay

Horizontally recirculating swimming chamber

Side view



Acknowledgements

We thank the following for their support in this project:

- Jon Reardon
- Sarah Moffitt
- Christa Lindsey
- Nick Buckmaster
- Norm Ponferrada
- Andrew Kay
- Caitlin Kroeger
- Jose D. Rosa Jr.
- Rebecca Isquith
- Max Fish
- Juan Zamora

- The California Energy Commission's

Public Interest Energy Research (PIER) Program

Water Intake Structure Environmental Research (WISER) Program

and

-The University of California at Davis

Center for Aquaculture and Aquatic Biology