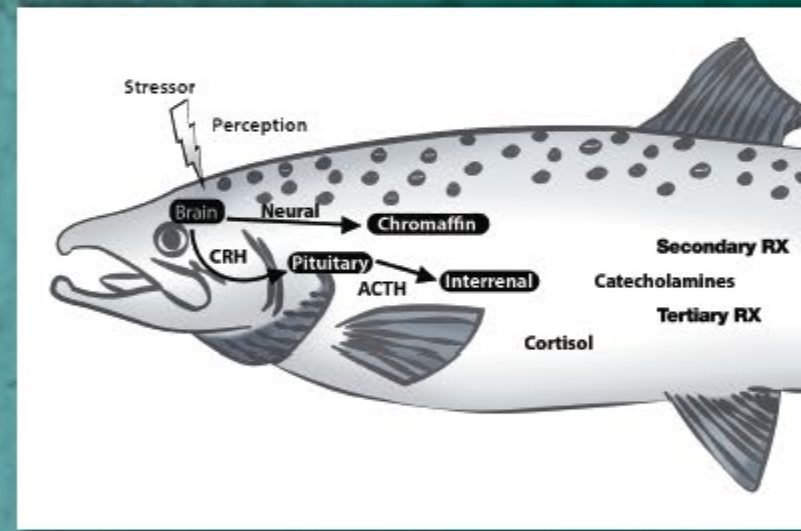


# STRESS!

Seeking Cures for Modern Anxieties

Biology of Stress & Relevance to  
Willamette Recovery Programs

# Biology of Stress in Fish



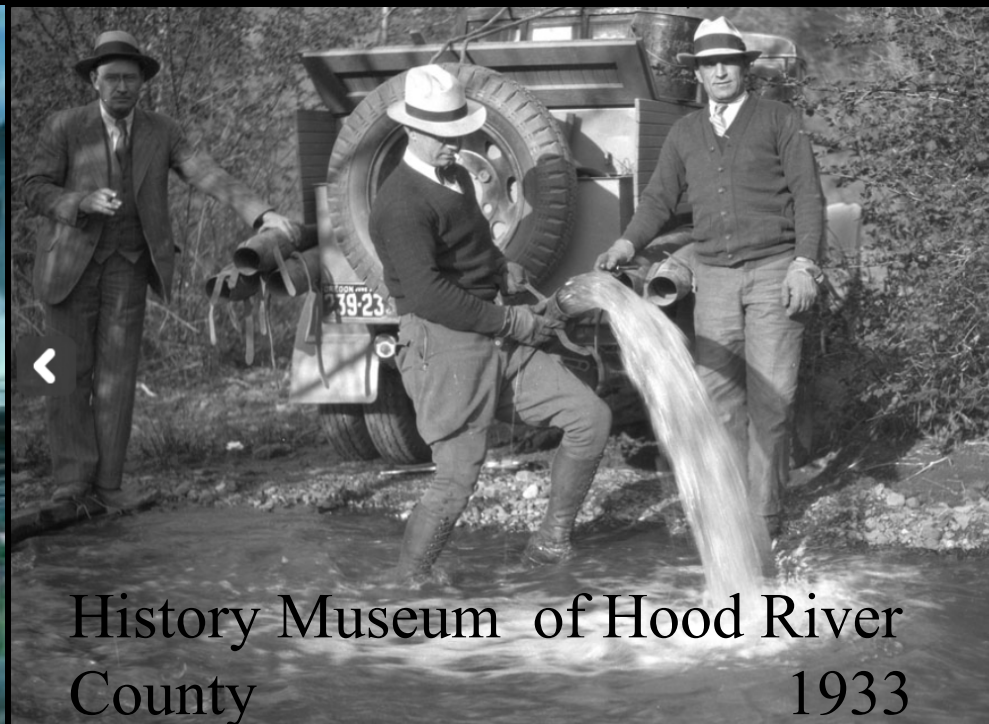
Researching stress  
For a while

Carl B. Schreck, Lluís Tort,  
Anthony P. Farrell and Colin J. Brauner

SERIES EDITORS: Anthony P. Farrell and Colin J. Brauner



Refereed publications relevant to  
trap & haul & bypass:  
117 out of >300 total



History Museum of Hood River  
County 1933

# Stress

**“The non-specific response of the body to any demand placed upon it”**

Selye

# Stress

**“The physiological cascade of events that occurs when the organism is attempting to resist death or reestablish homeostatic norms in the face of insult”**

Schreck

# Phases of Stress

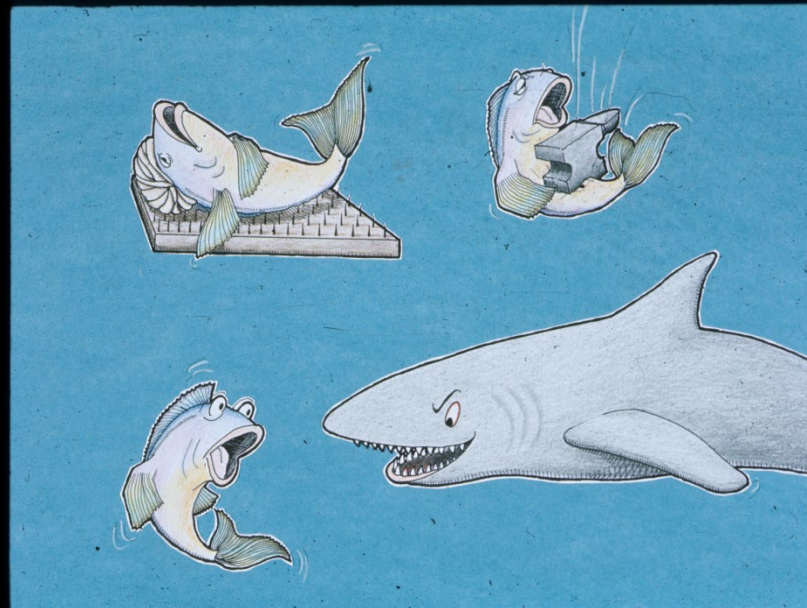
❖ **Alarm**

❖ **Resistance**

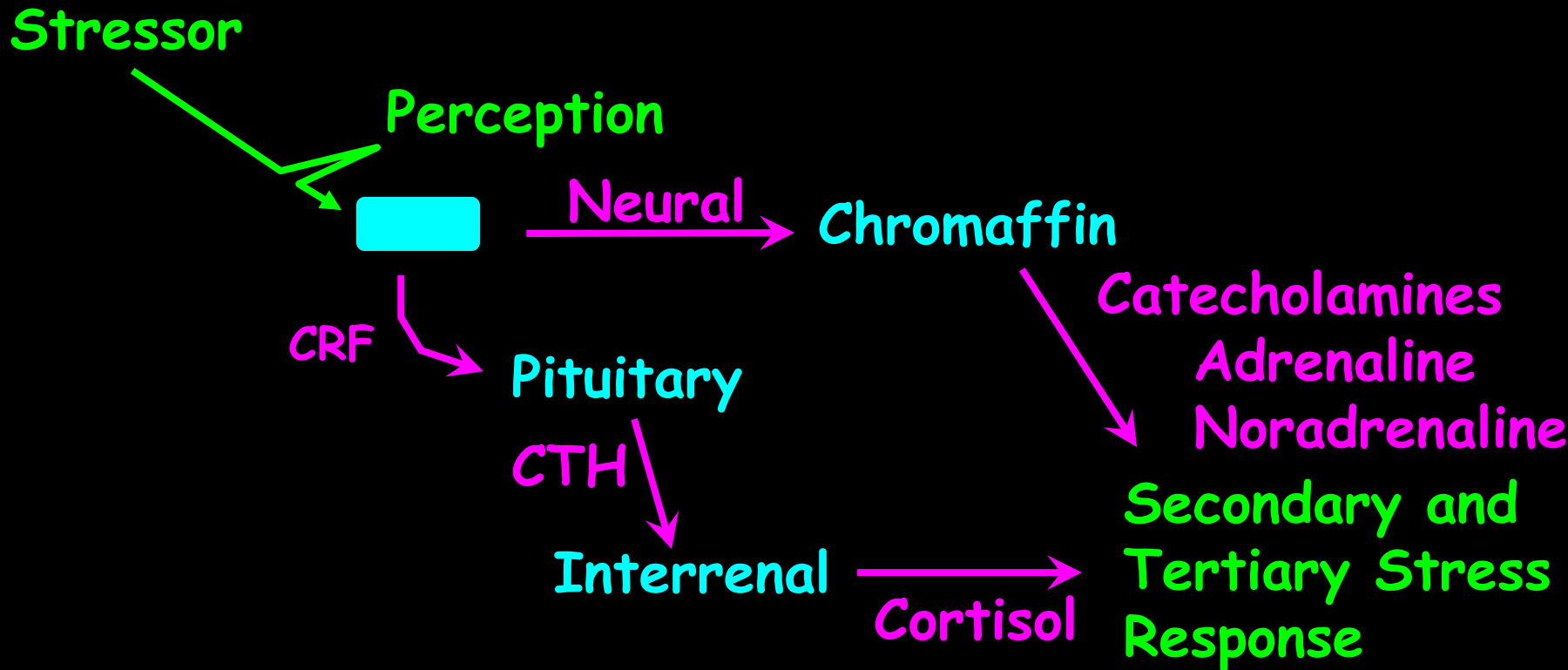
❖ **Compensation/Recovery or Exhaustion**

# Stress is

- **Rx to stressor & a function of the animals genetics, history, and present environment**



# Stress Response





# Stress Response

Primary

Cortisol

Catecholamines

Secondary

Energy

Glucose  
Lactate  
Cardiovascular  
FFA, Pr.

Hydromineral

Water ↑ ↓  
Na ↑ ↓  
K  
Gill vascularization

Immune

Redistribution  
Suppression

Tertiary

Disease Rx

AB ↓ ↑

Behavior

Learning ↑ ↓  
Predator avoidance ↓  
Migration ↓

Development

Retarded

Growth

Hypertrophy ↓  
Hyperplasia ↓  
Apoptosis ↑

Reproduction

Accelerated  
Inhibited  
Fecundity ↓

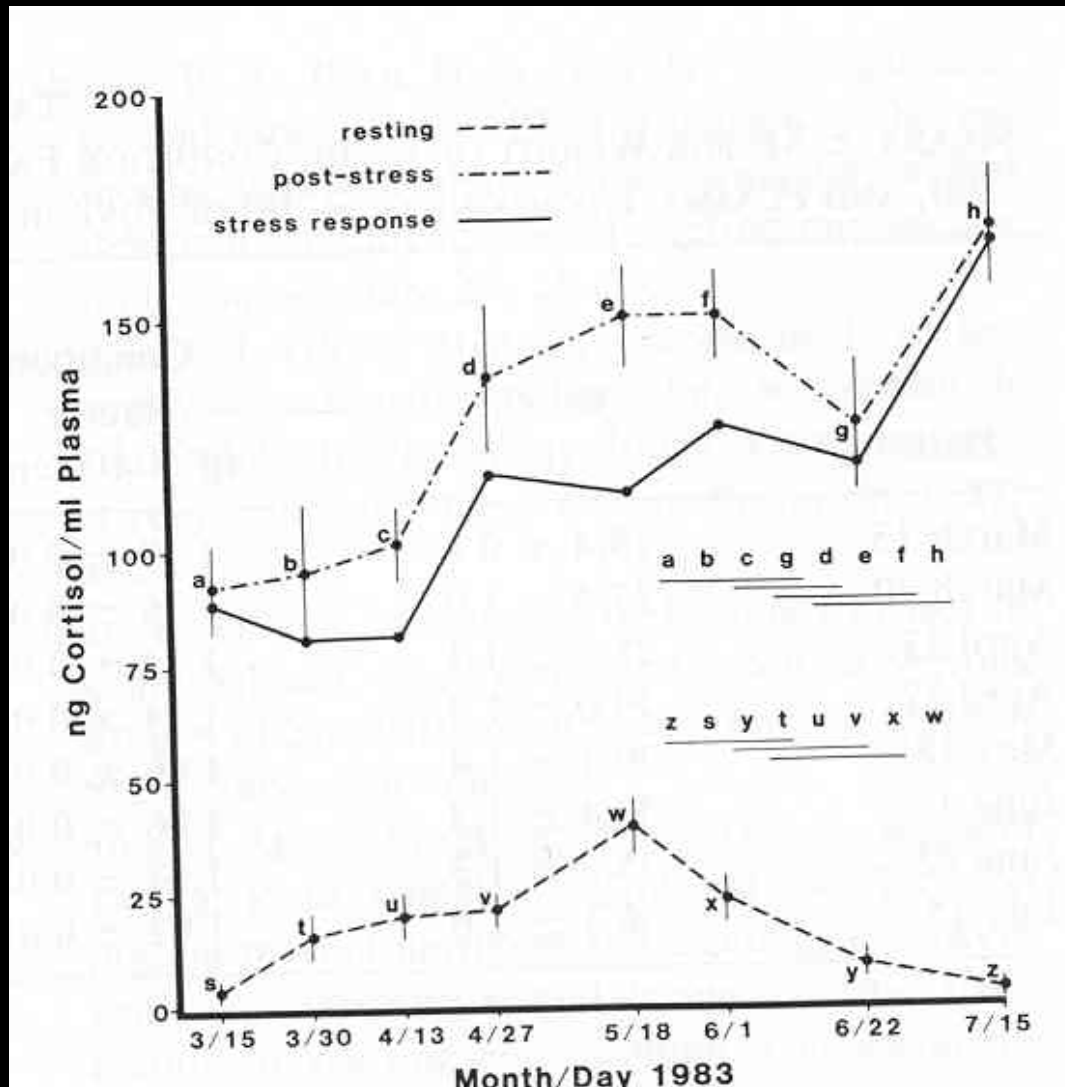
# Energy Cost of Stress Huge

Energy not available for:

- Migration
- Disease resistance
- Growth
- Smolting
- Reproduction
- Learning (imprinting)

# Developmental stage matters

## Smolts very vulnerable



Barton et al.

Stress causes disease easier during smolting

# PERCEPTION



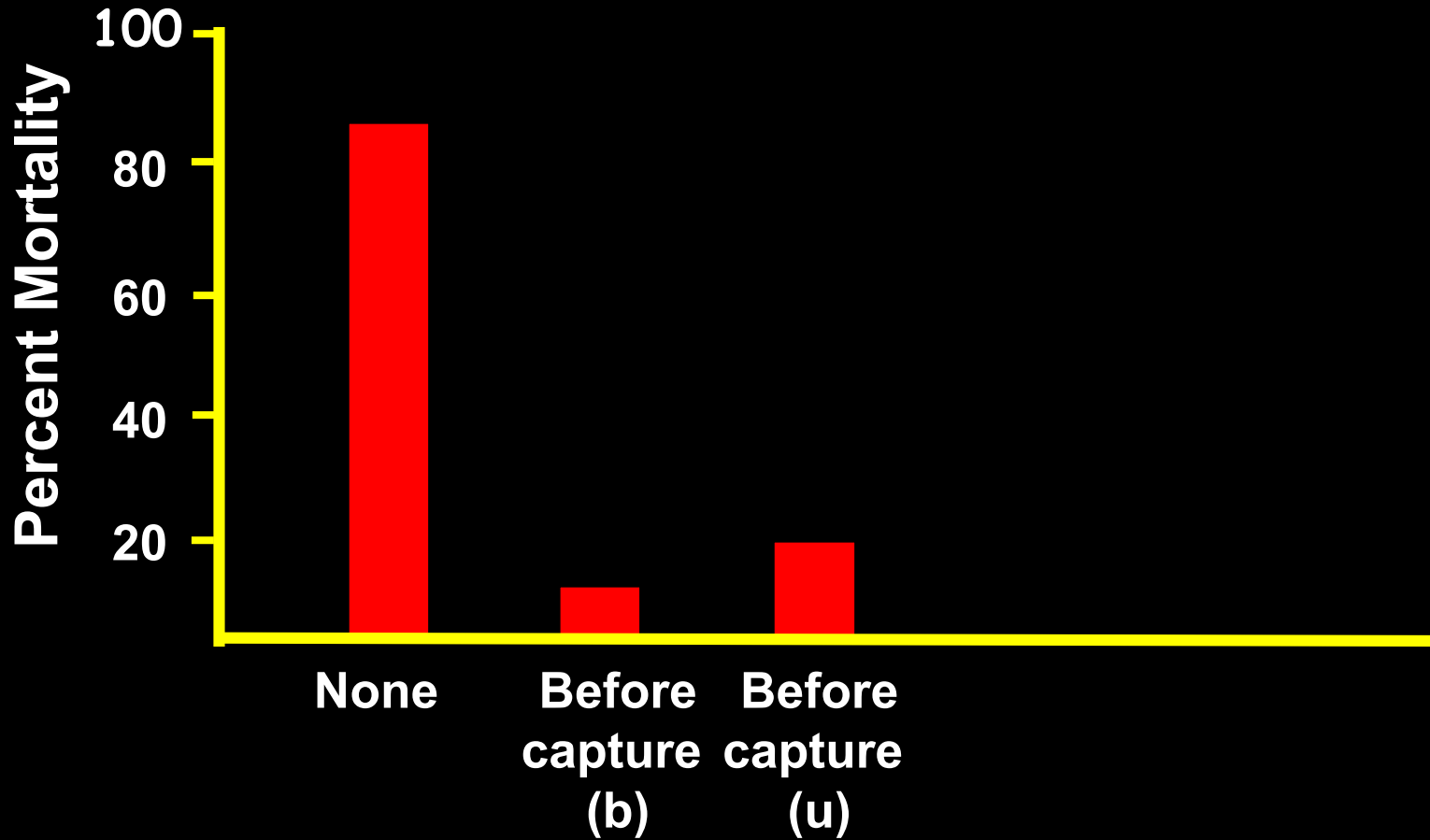
If threat is real or not doesn't matter

# How do we know?



- Net capture, bucket transport, 24 h shallow water confinement
- Anesthetic before net capture, air, 24 h confinement
- Anesthetic after net capture & air, then 24 h confinement

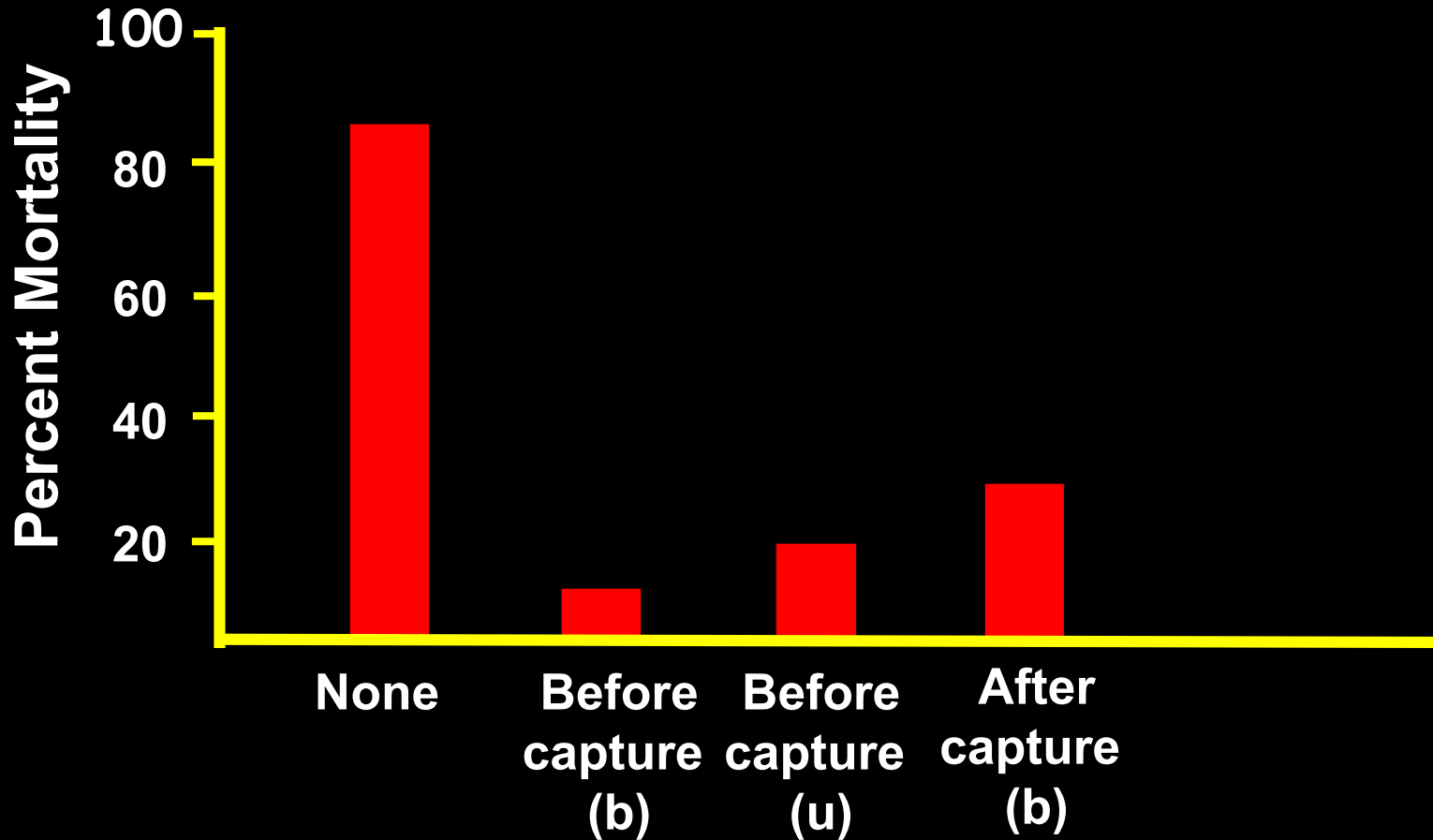
# Effect of Anesthetics on Capture and Crowding 24 hr



MS 222 Anesthetic Treatment

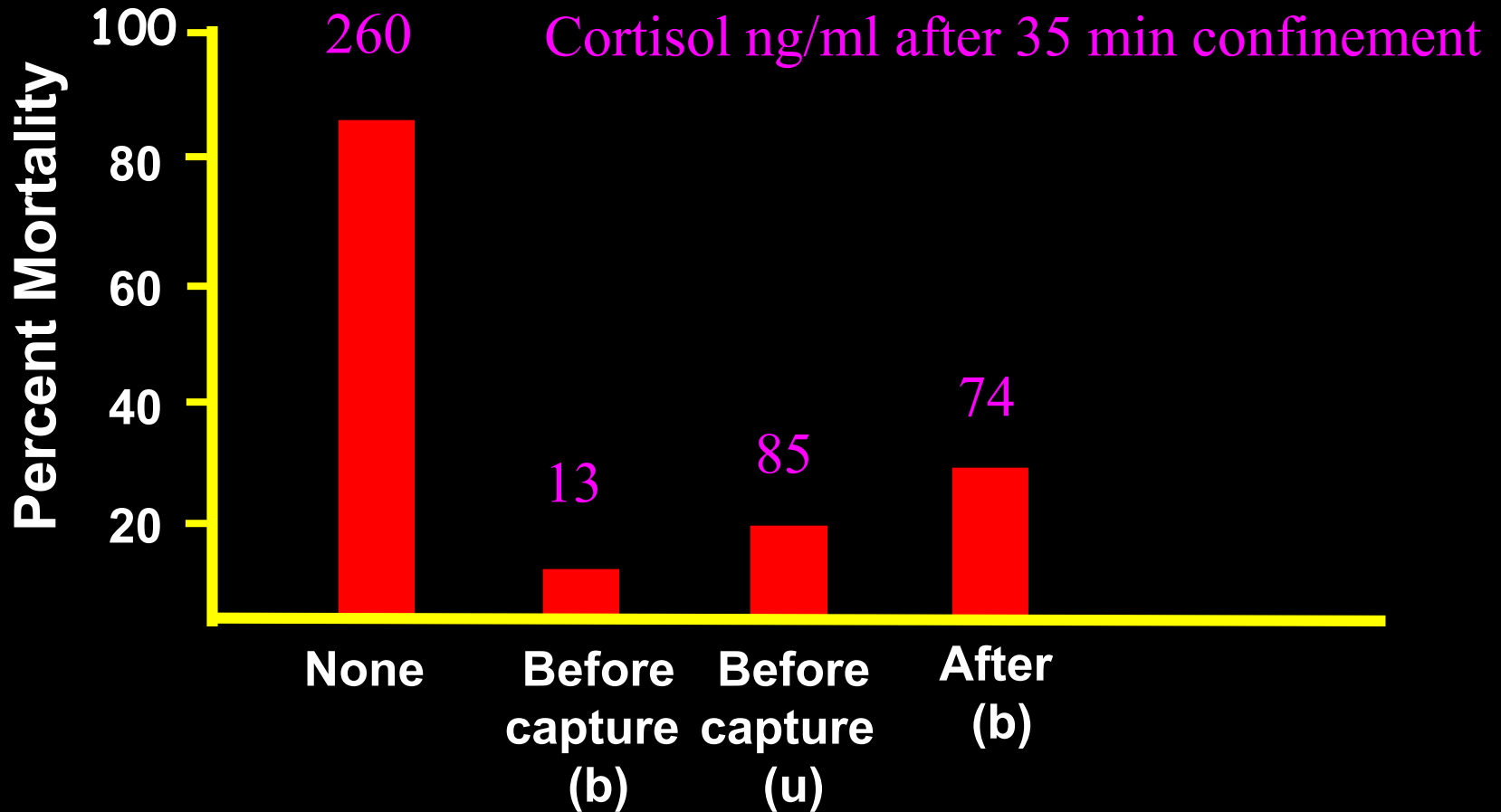
Strange & Schreck

# Effect of Anesthetics on Capture and Crowding 24 hr



MS 222 Anesthetic Treatment

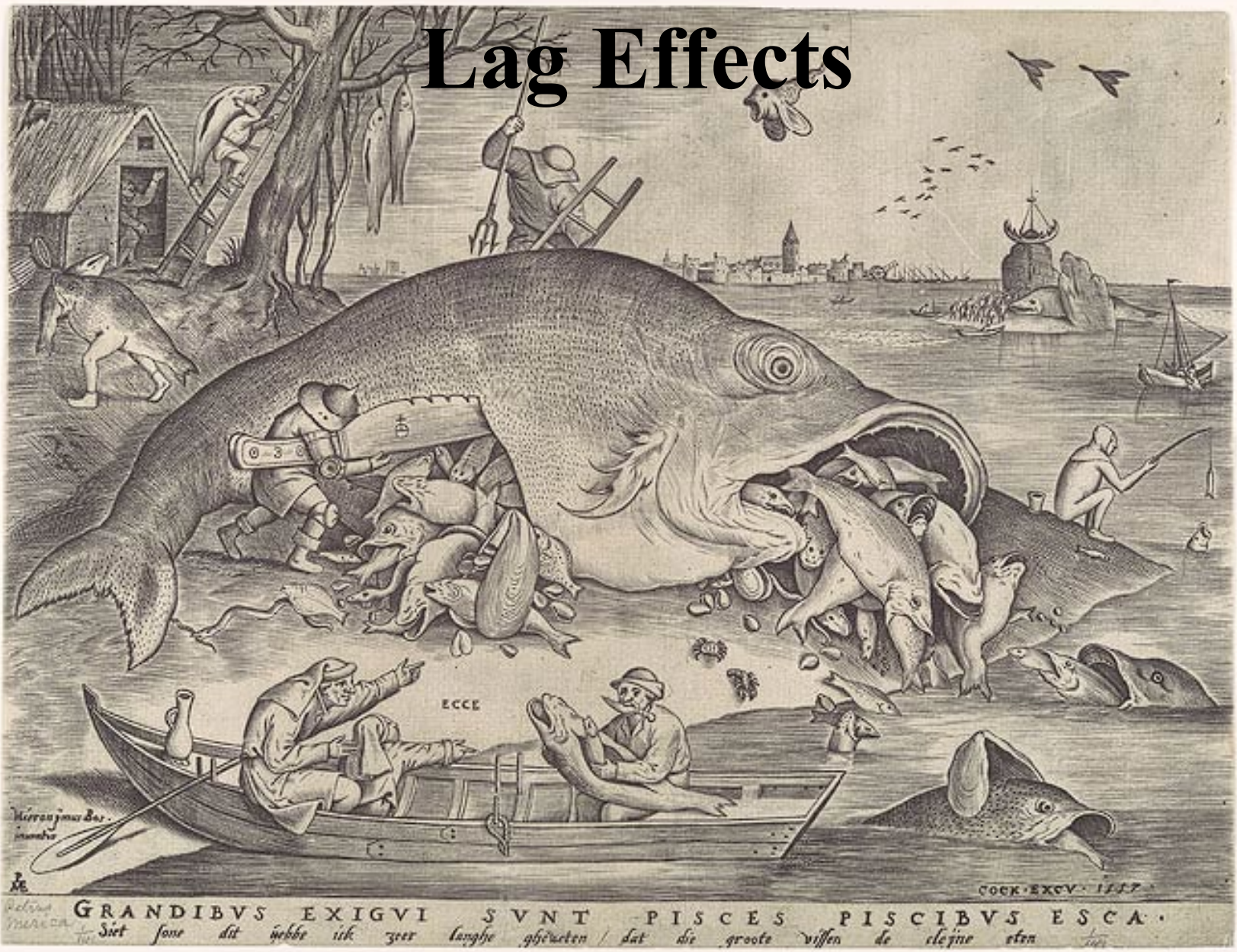
# Effect of Anesthetics on Capture and Crowding 24 hr



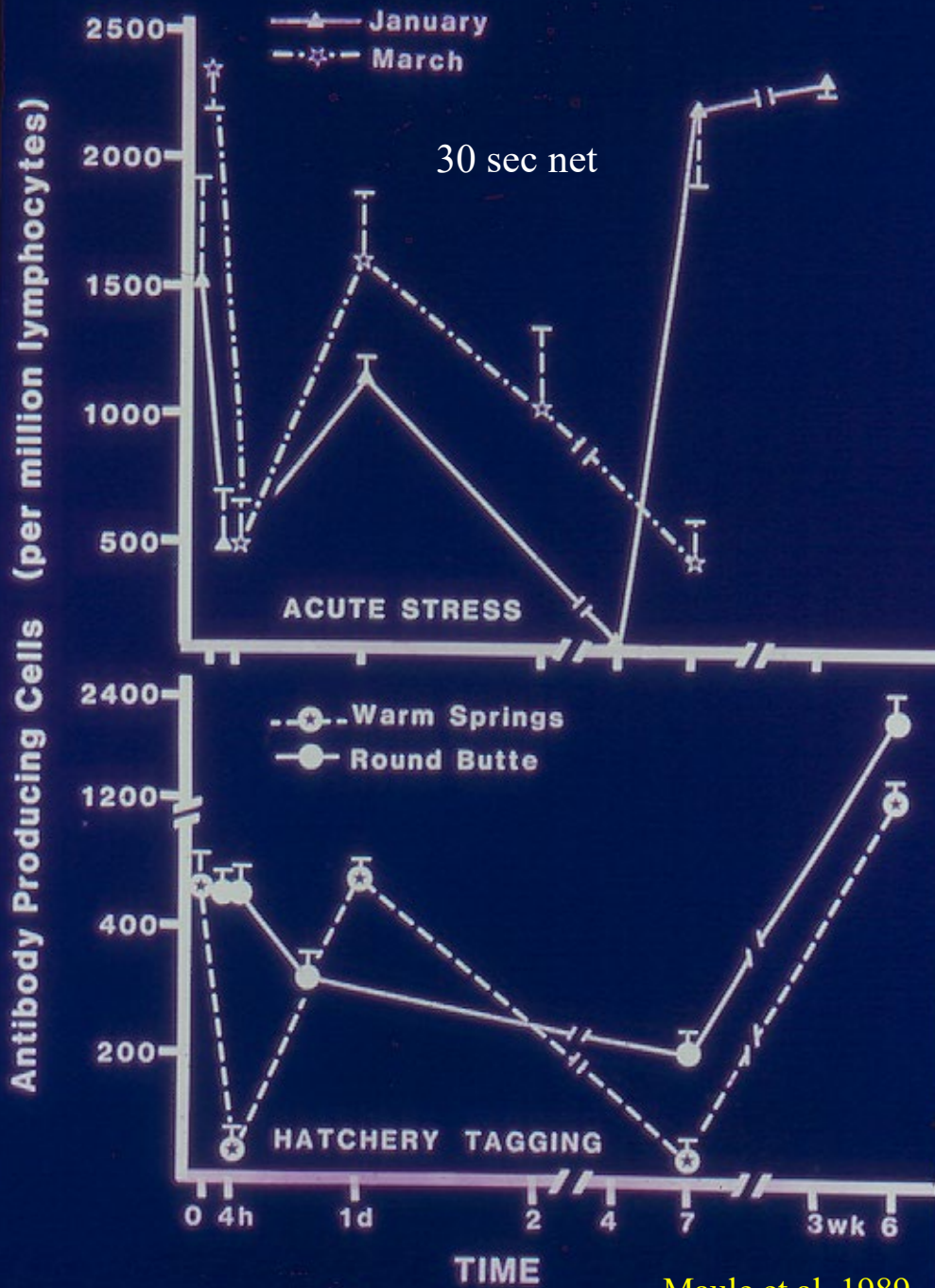
MS 222 Anesthetic Treatment



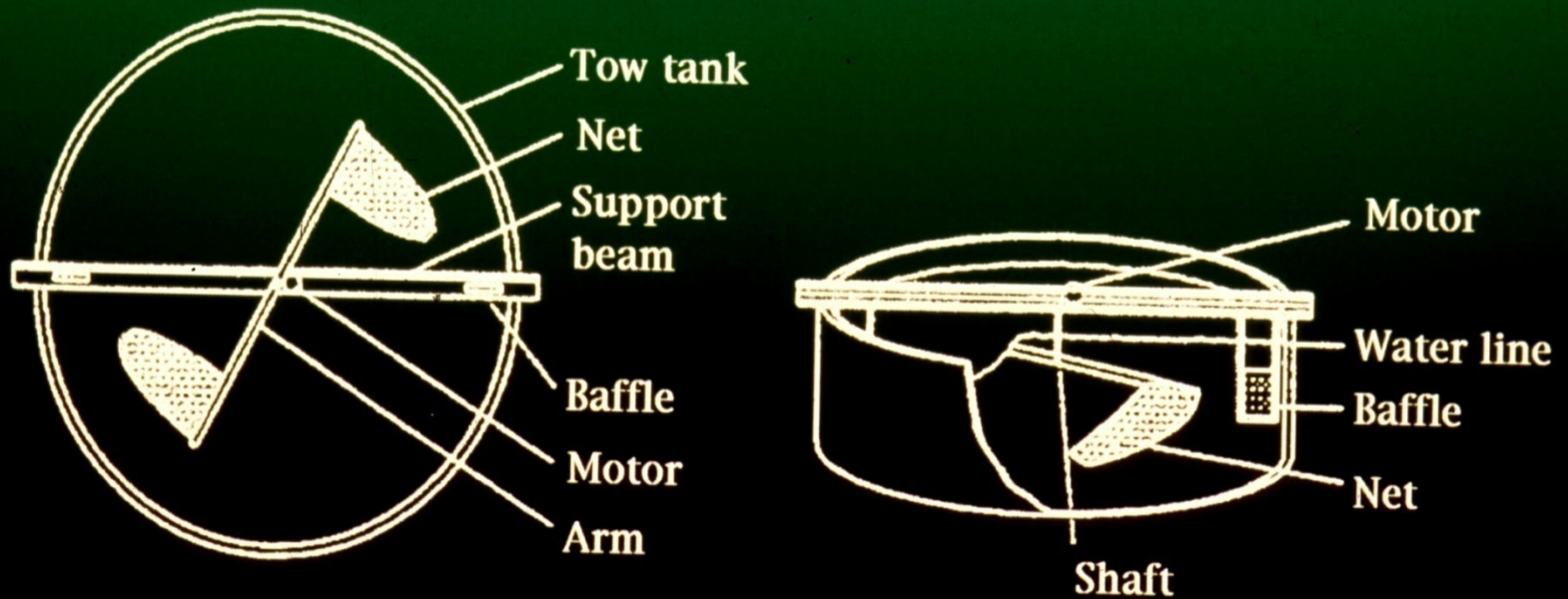
# Lag Effects



Pieter Bruegel, 1557  
Big Fish Eat Little Fish

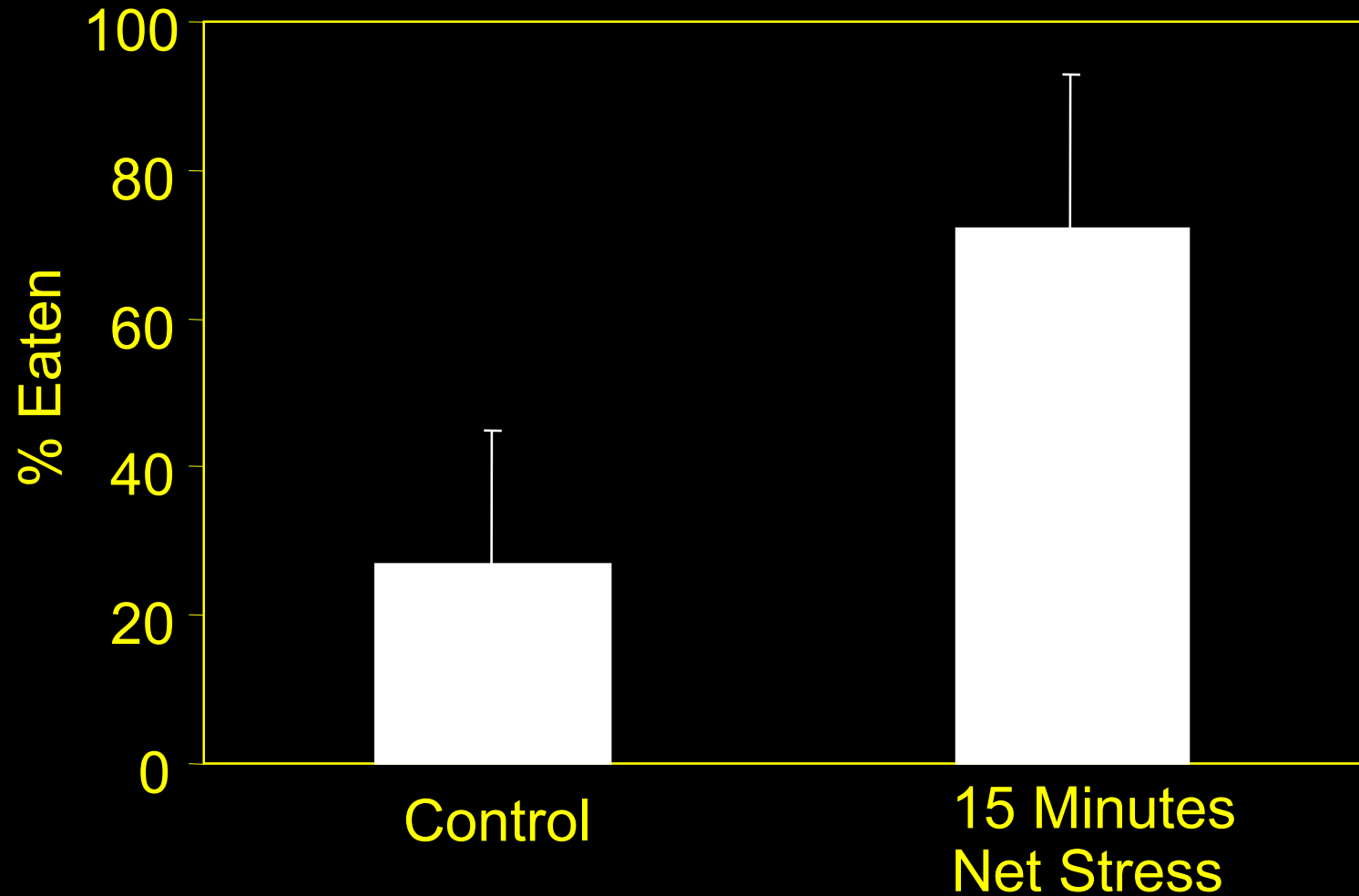


# Simulated Trawl Tank



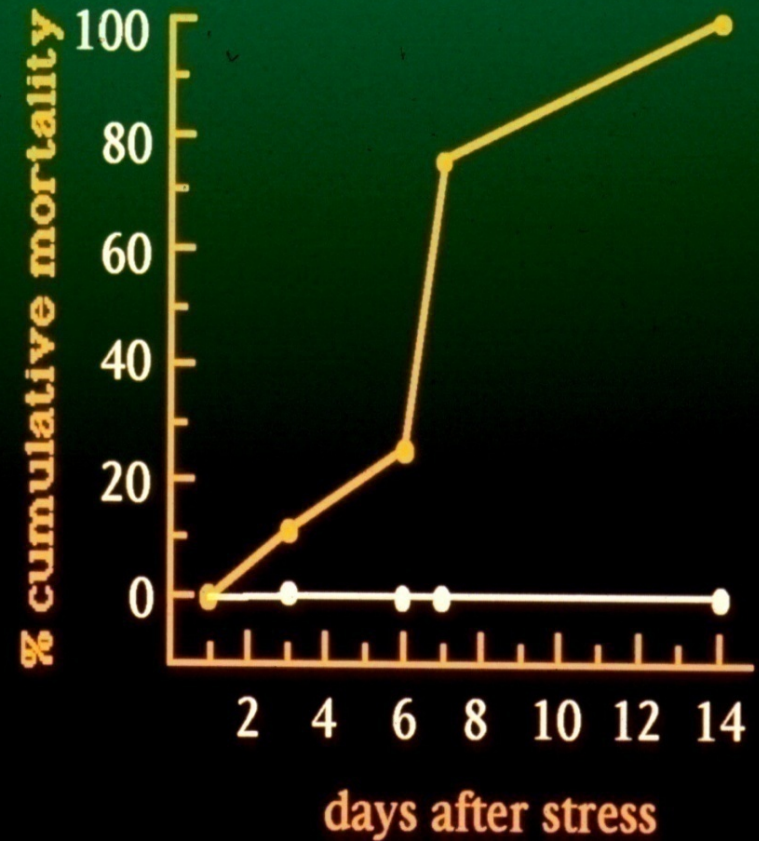
Behavioral Impairment  
Predator Avoidance

# EFFECT OF SIMULATED TRAWLING ON PREDATOR AVOIDANCE IN WALLEYE POLLOCK

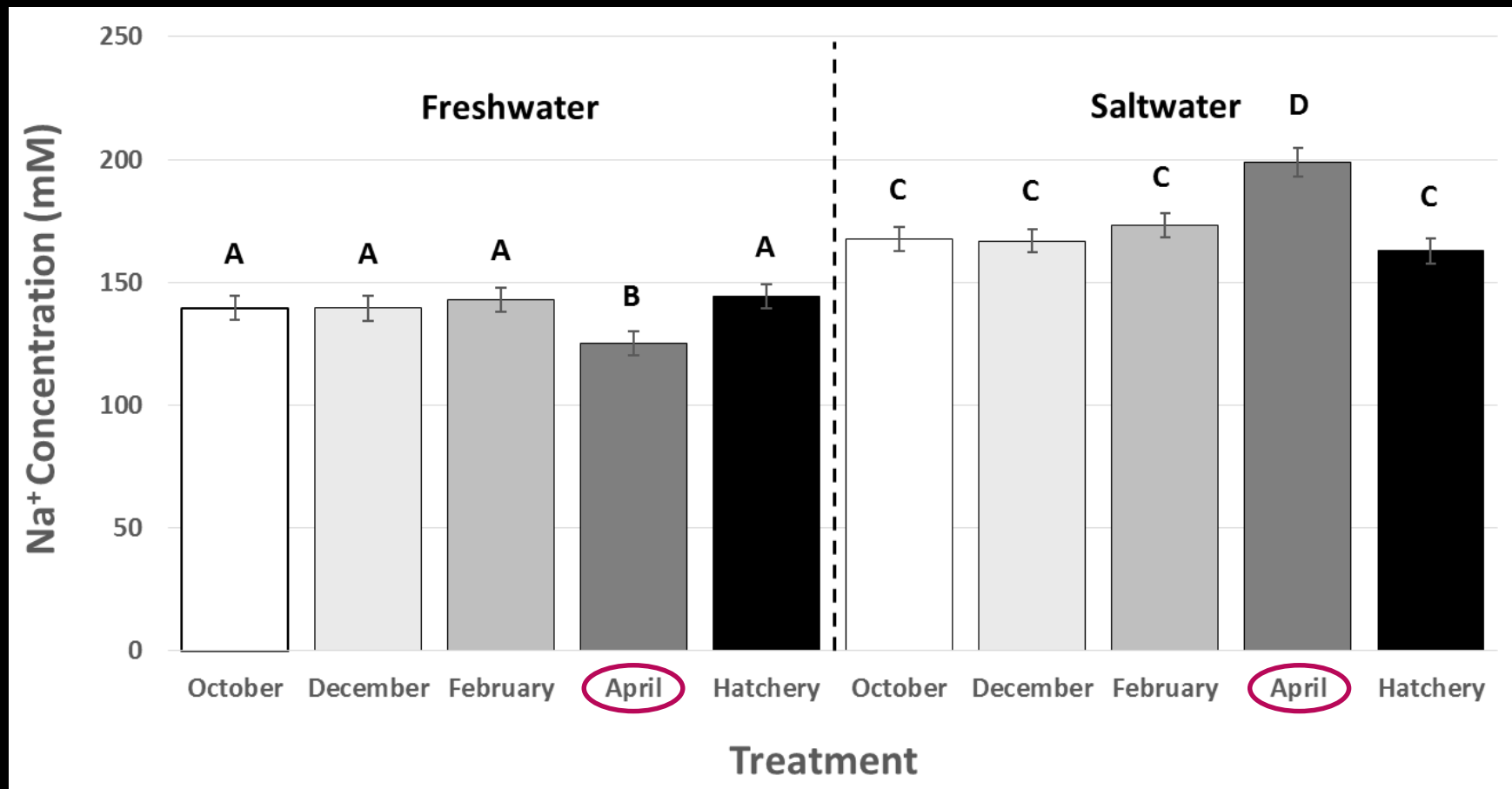


## Effect of 15 min Towing Stress (in light) on Walleye Pollock

Bycatch capture &  
release effects



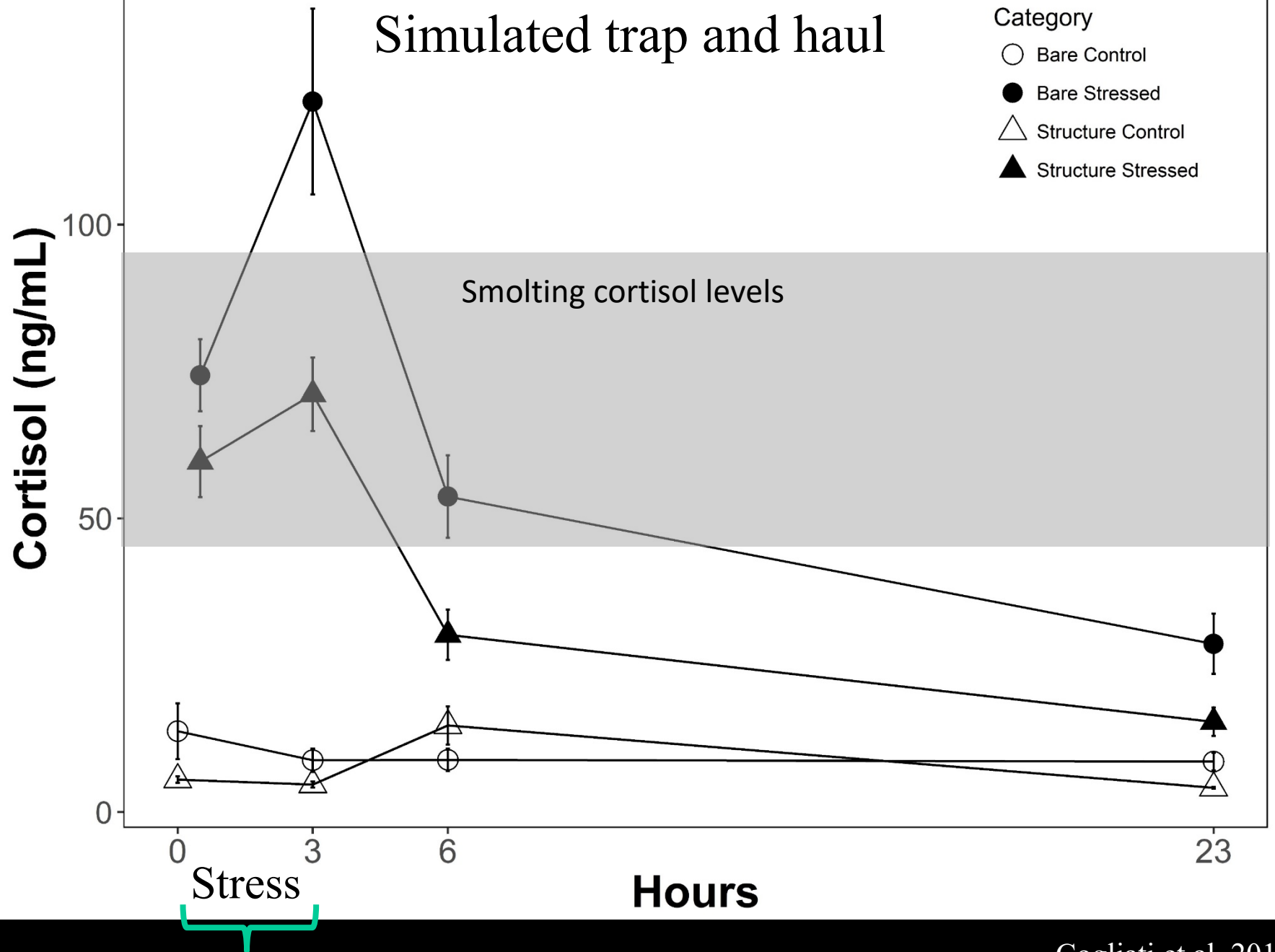
# Chinook Transport to Marion Forks



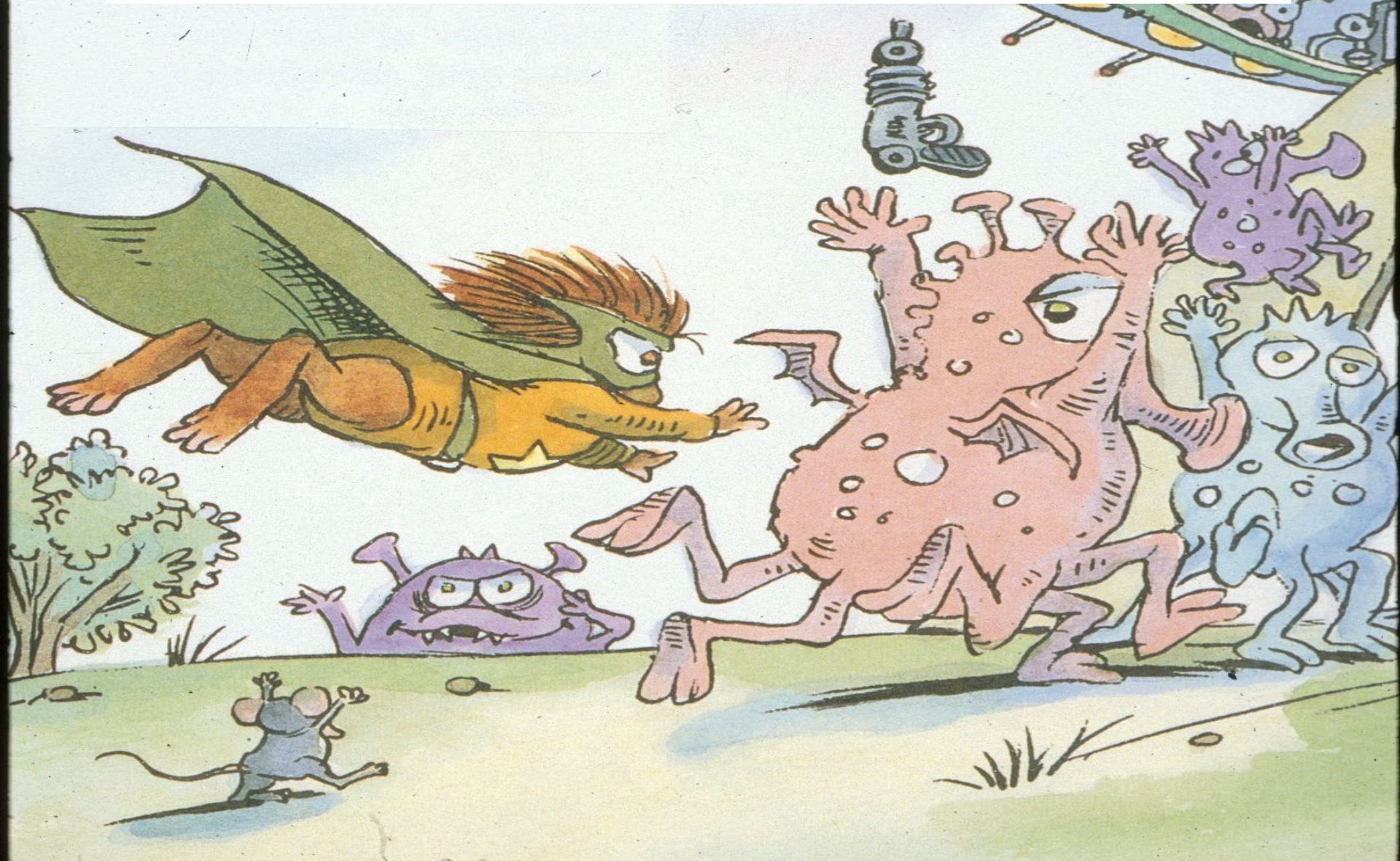
Transport month & saltwater challenged in May

•Effect 3 to 8 weeks

# Simulated trap and haul



Unexpected but relevant stressors





# The social environment matters:

- Density/Crowding important
- Chinook are quite pacifistic
- Steelhead beat up on each other & Chinook

3 Hours  
After Loading  
Steelhead Only



**FISH CAN HEAR INFRASOUND—CAUSE FEAR  
AS FROM 60 CYCLE MOTORS/GENERATORS**

# Color can affect stress level

Green & Blue good

Green vs White

Green & Blue vs  
White or Red

Green vs white or red

MARINE AND FRESHWATER BEHAVIOUR AND PHYSIOLOGY, 2016  
VOL. 49, NO. 4, 223–234  
<http://dx.doi.org/10.1080/10236244.2016.1168036>



Taylor & Francis  
Taylor & Francis Group

## The effect of green and red light spectra and their intensity on the oxidative stress and non-specific immune responses in gold-striped amberjack, *Seriola lalandi*

Young Jae Choi<sup>a</sup>, Ji Yong Choi<sup>a</sup>, Sang-Geun Yang<sup>b</sup>, Bong-Seok Kim<sup>b</sup> and Cheol Young Choi<sup>a</sup>



ELSEVIER

Contents lists available at [ScienceDirect](#)

Fish & Shellfish Immunology

journal homepage: [www.elsevier.com/locate/fsi](http://www.elsevier.com/locate/fsi)



Full length article

Effects of different light wavelengths from LEDs on oxidative stress and apoptosis in olive flounder (*Paralichthys olivaceus*) at high water temperatures



Bong-Seok Kim<sup>a</sup>, Seo Jin Jung<sup>b</sup>, Young Jae Choi<sup>b</sup>, Na Na Kim<sup>b</sup>, Cheol Young Choi<sup>b,\*</sup>, Jae-Woo Kim<sup>a</sup>



ELSEVIER

Contents lists available at [ScienceDirect](#)

Fish & Shellfish Immunology

journal homepage: [www.elsevier.com/locate/fsi](http://www.elsevier.com/locate/fsi)



Full length article

Effects of melatonin injection or green-wavelength LED light on the antioxidant system in goldfish (*Carassius auratus*) during thermal stress



Seo Jin Jung<sup>a</sup>, Young Jae Choi<sup>a</sup>, Na Na Kim<sup>a</sup>, Ji Yong Choi<sup>a</sup>, Bong-Seok Kim<sup>b</sup>, Cheol Young Choi<sup>a,\*</sup>

# Shade or darkness good for salmonids

You're stressing me out Carl; I'm not wearing shades like you

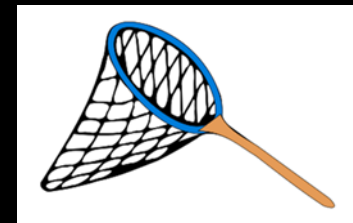
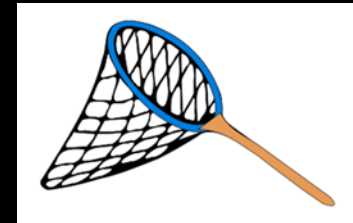


# REPEATED

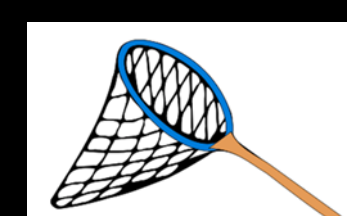
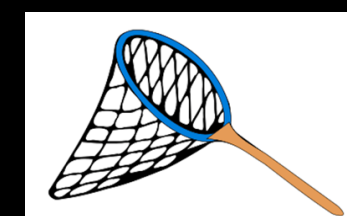
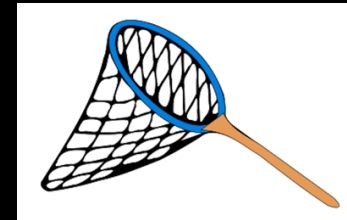
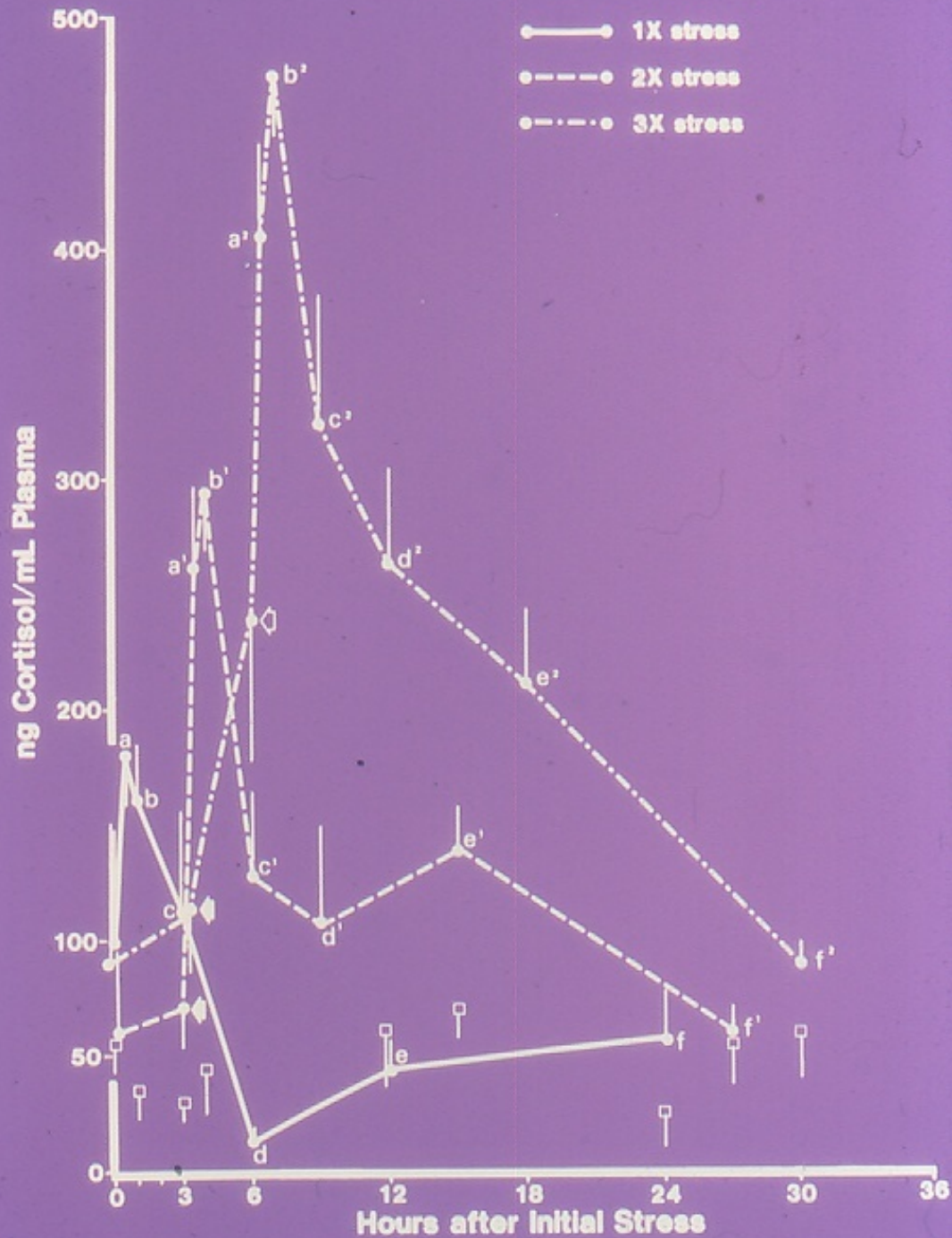
STRESSOR



TIME

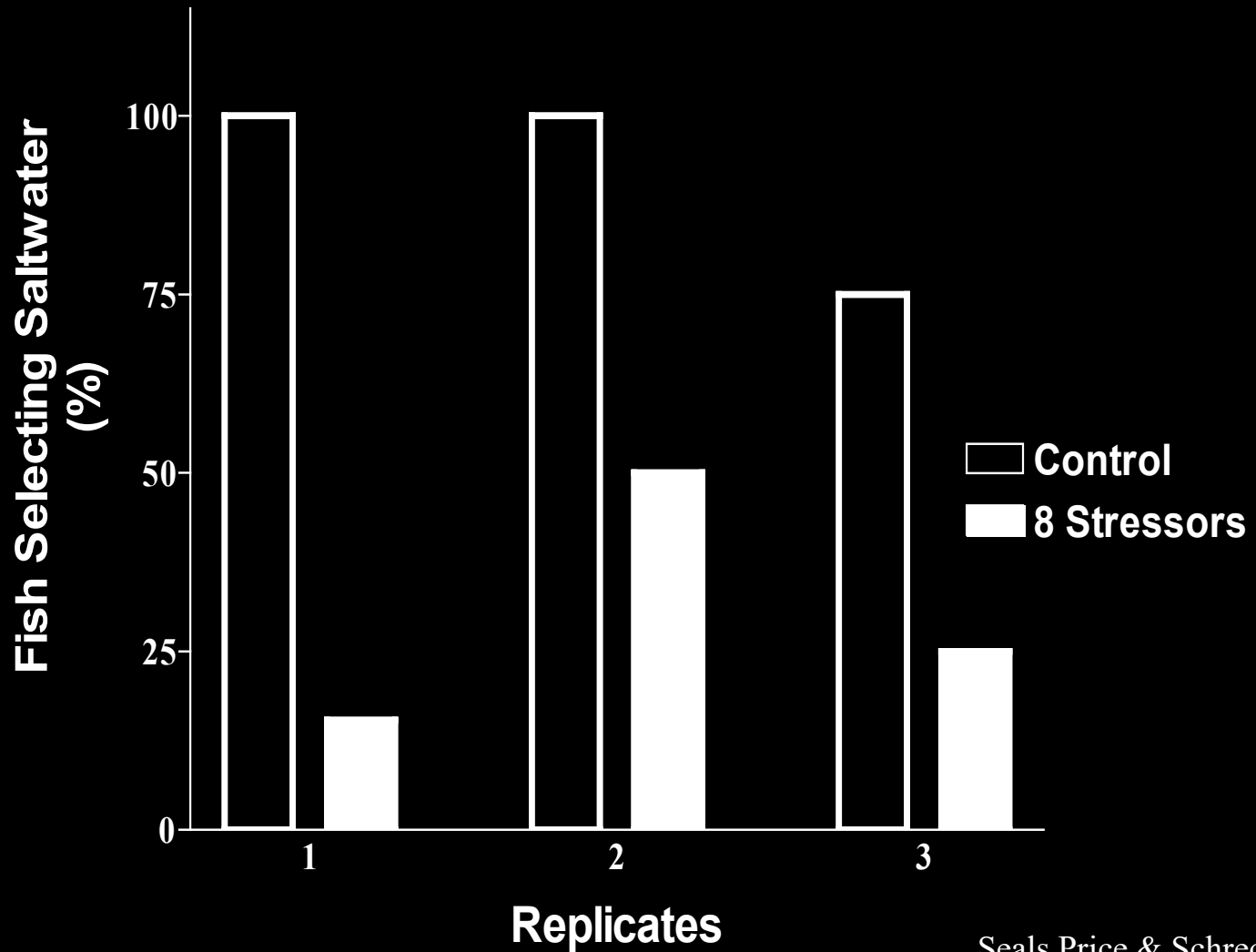


Can have cumulative effects



Barton & Schreck

# Effects of Multiple Dam Passage Saltwater Preference



# HABITUATION & CONDITIONING

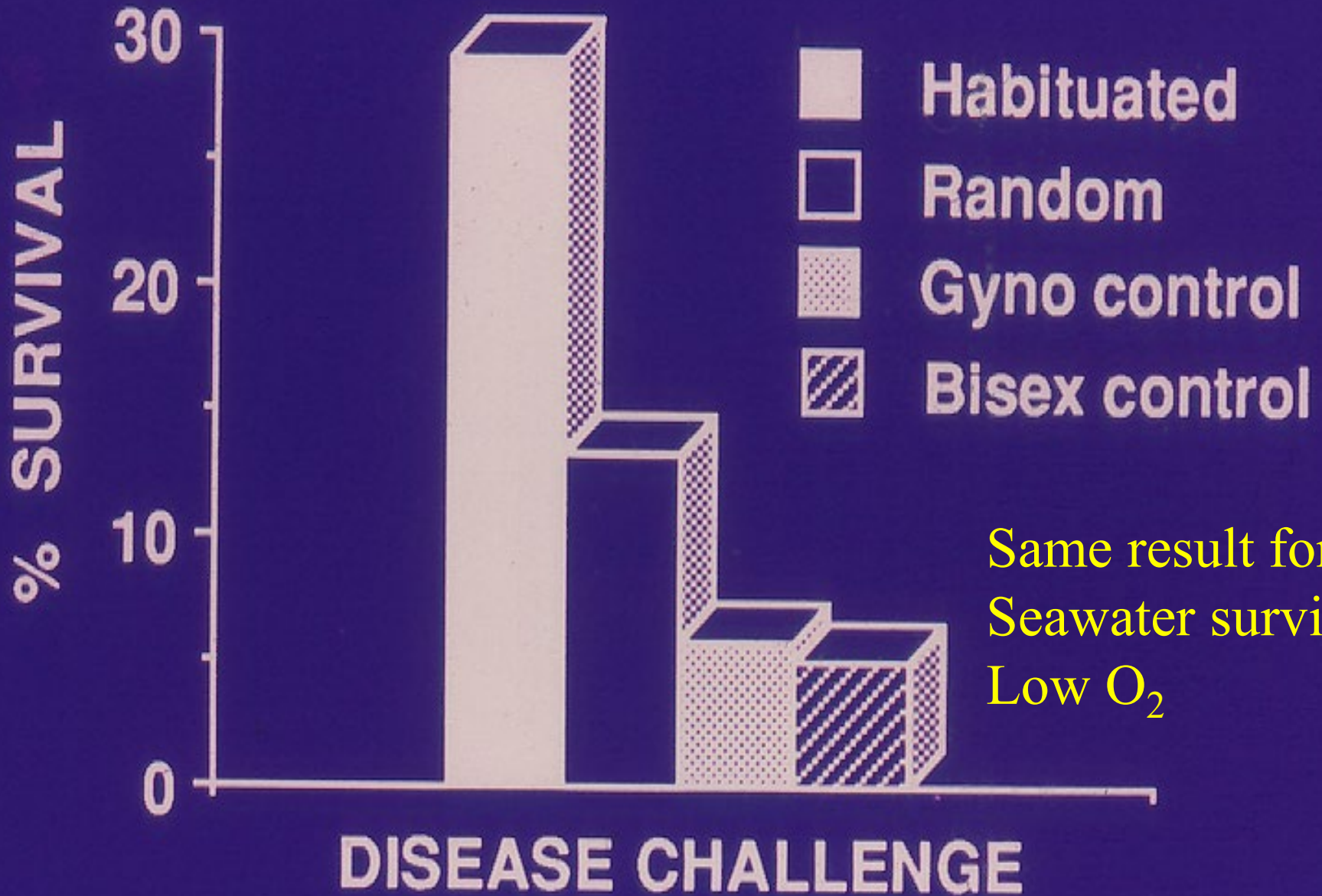
➤ PHYSICAL CONDITIONING

➤ MENTAL CONDITIONING

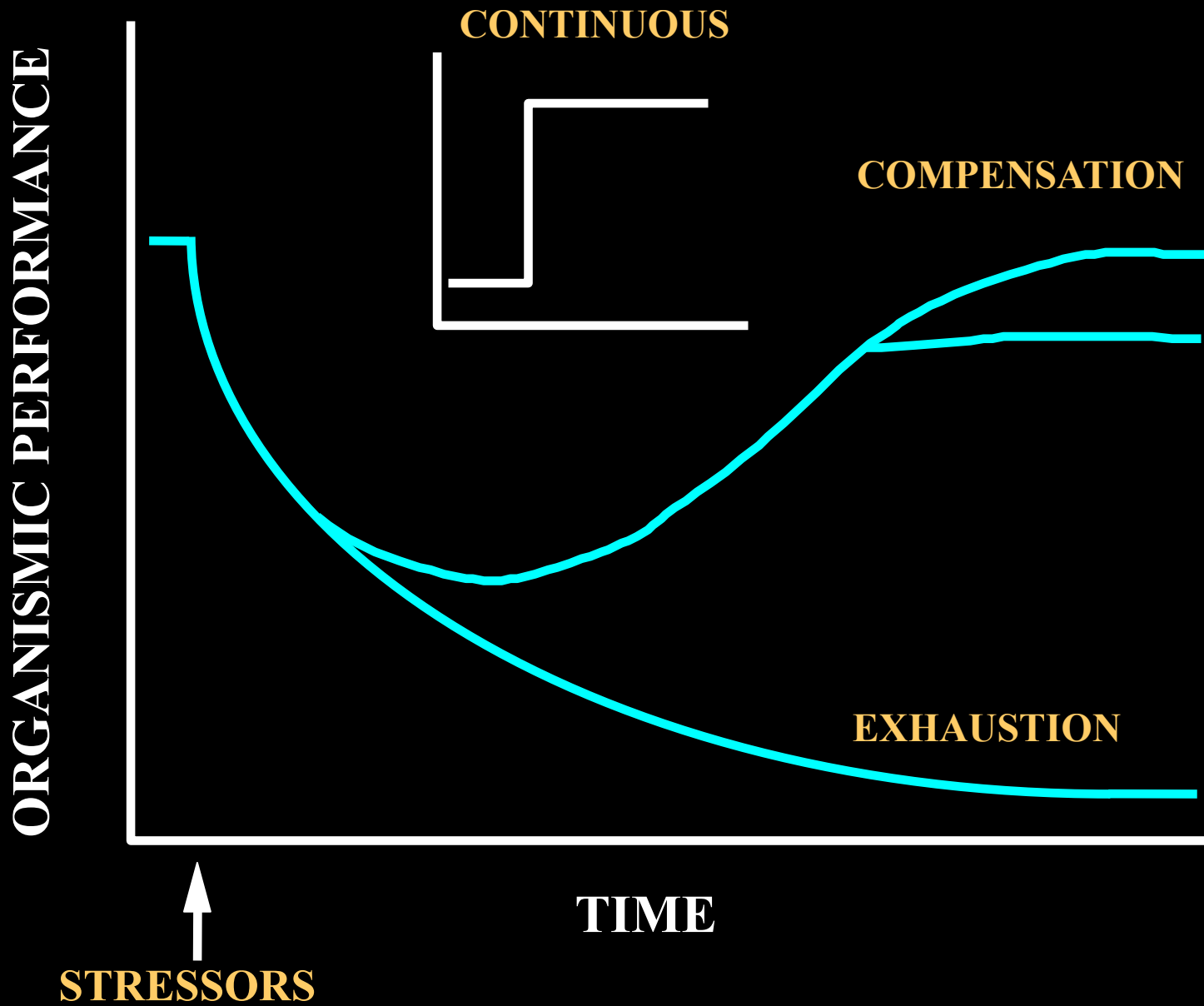
➤ STRESS HARDENING



# "Trap" & Haul 1.5 Hr



Same result for:  
Seawater survival  
Low O<sub>2</sub>



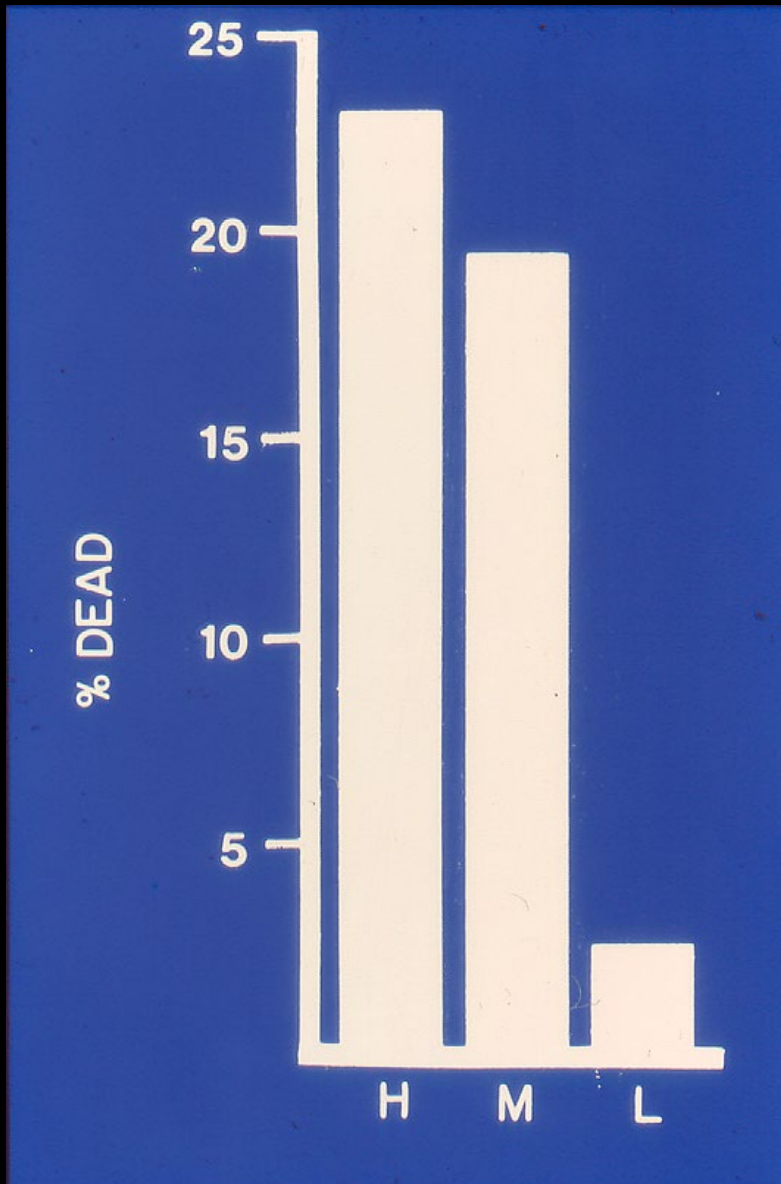
# Social Environment

Coho hierarchy



Very high density  
eliminates capacity  
to form heierarchy

# REARING DENSITY Willard NFH



H = Production density

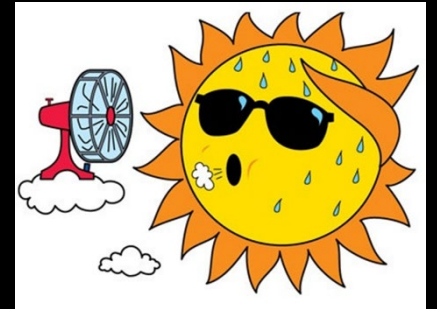
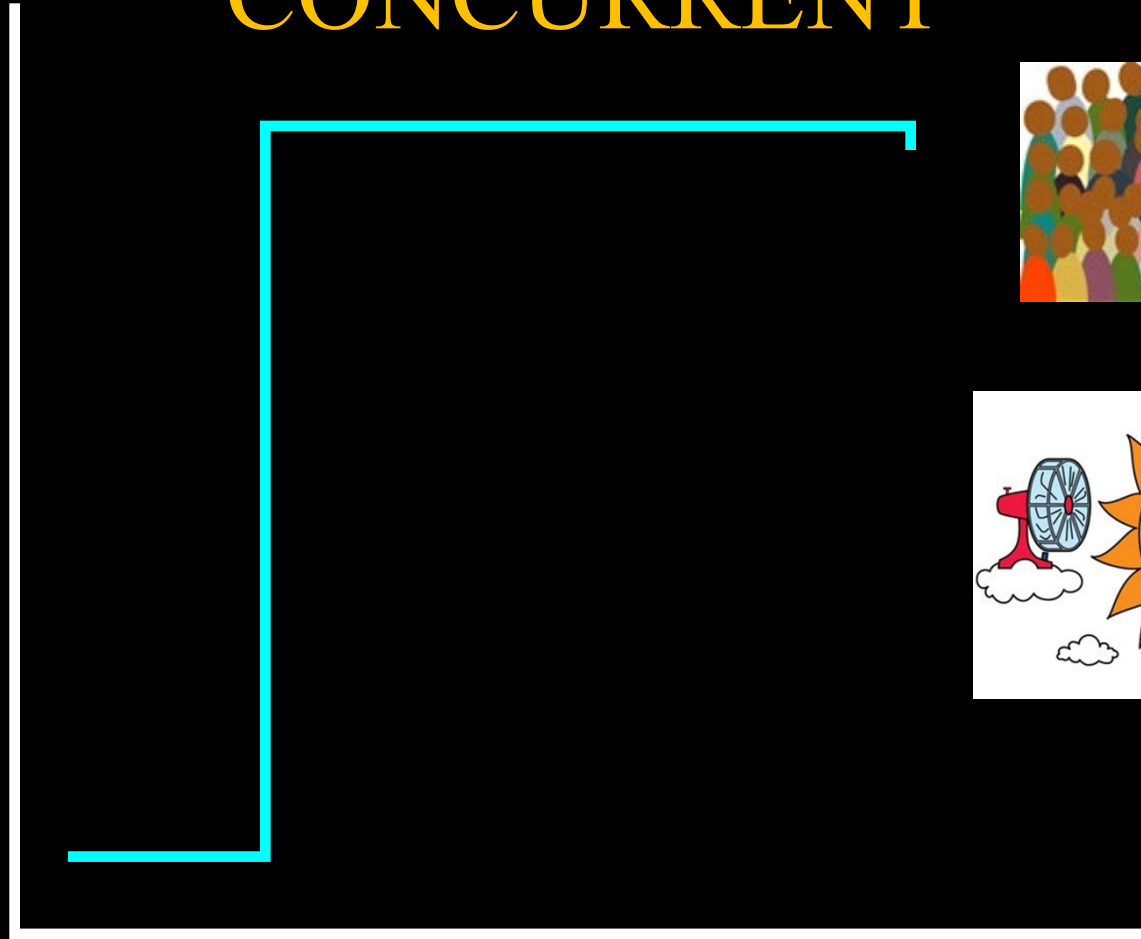
M =  $2/3$  Production density

L =  $1/3$  Production density

**Vibriosis**

# CONCURRENT

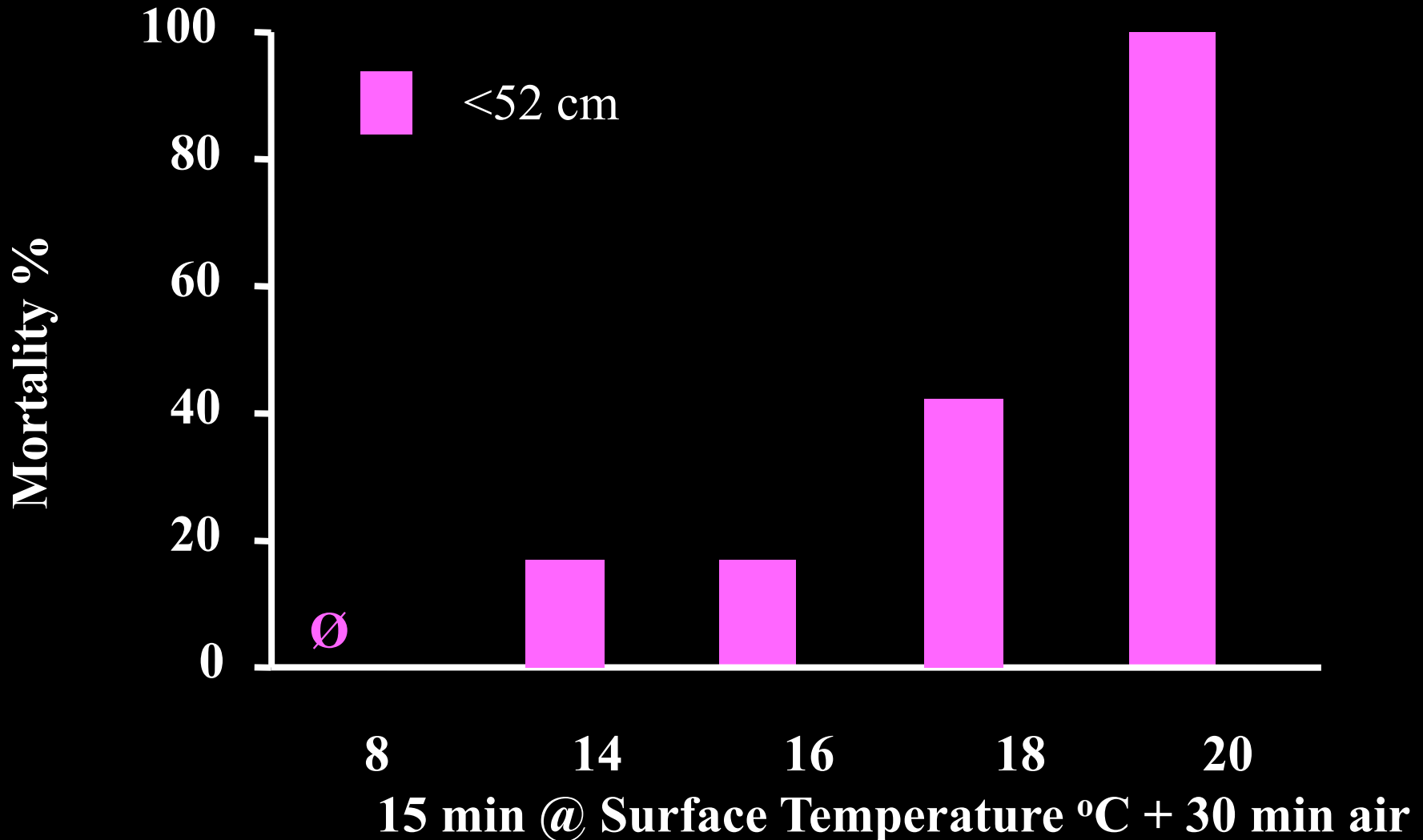
STRESSOR



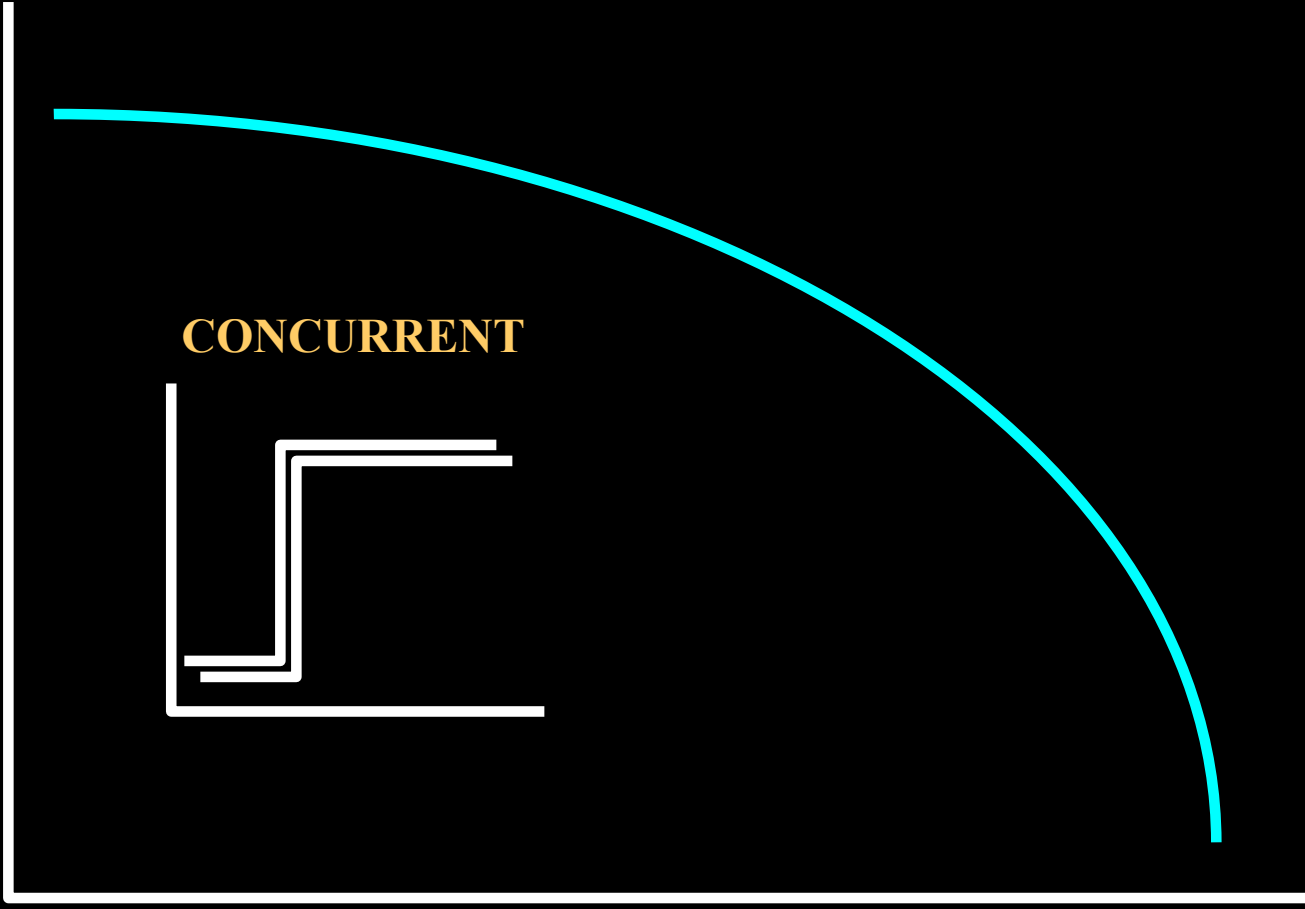
TIME

# Lingcod Bycatch, caught @ 8 °C

Think epilimnion temperature



**ORGANISMIC PERFORMANCE**



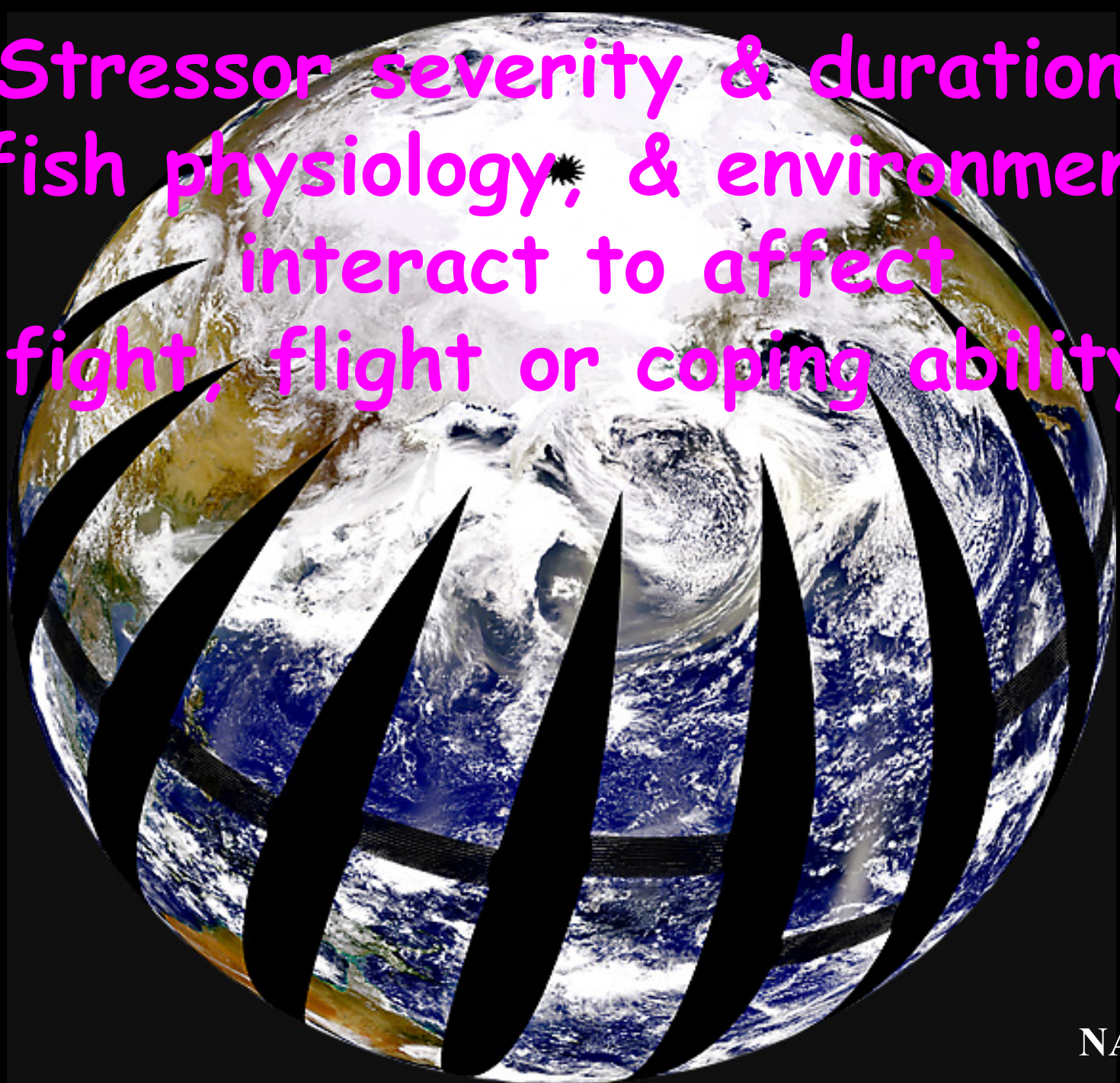
**STRESSOR 'A'**  
**(PROXIMITY TO TOLERANCE LIMITS)**

Don't think of the stress response  
as unimodal or even linear





Stressor severity & duration,  
fish physiology, & environment  
interact to affect  
fight, flight or coping ability



# Reflections on Stress



# The world according to Göpp Carl: re Stress

- Interpretation of stress is part art
- Good at knowing when stressed, not when free of stress—False negatives easy
- Consequences not linear often not unimodal
- Effects of individual stressors cumulate
- Consequences can be delayed effects



**Trap & Haul & Bypass  
according to Carl**

The strategy is trap & haul or  
bypass

Effectiveness of either depend on  
the success of the tactics employed

# The nature of the fish trap or guidance system matters



# Condition of fish encountering a trap or guidance system matters



Fish can be affected by fear of entering trap/bypass



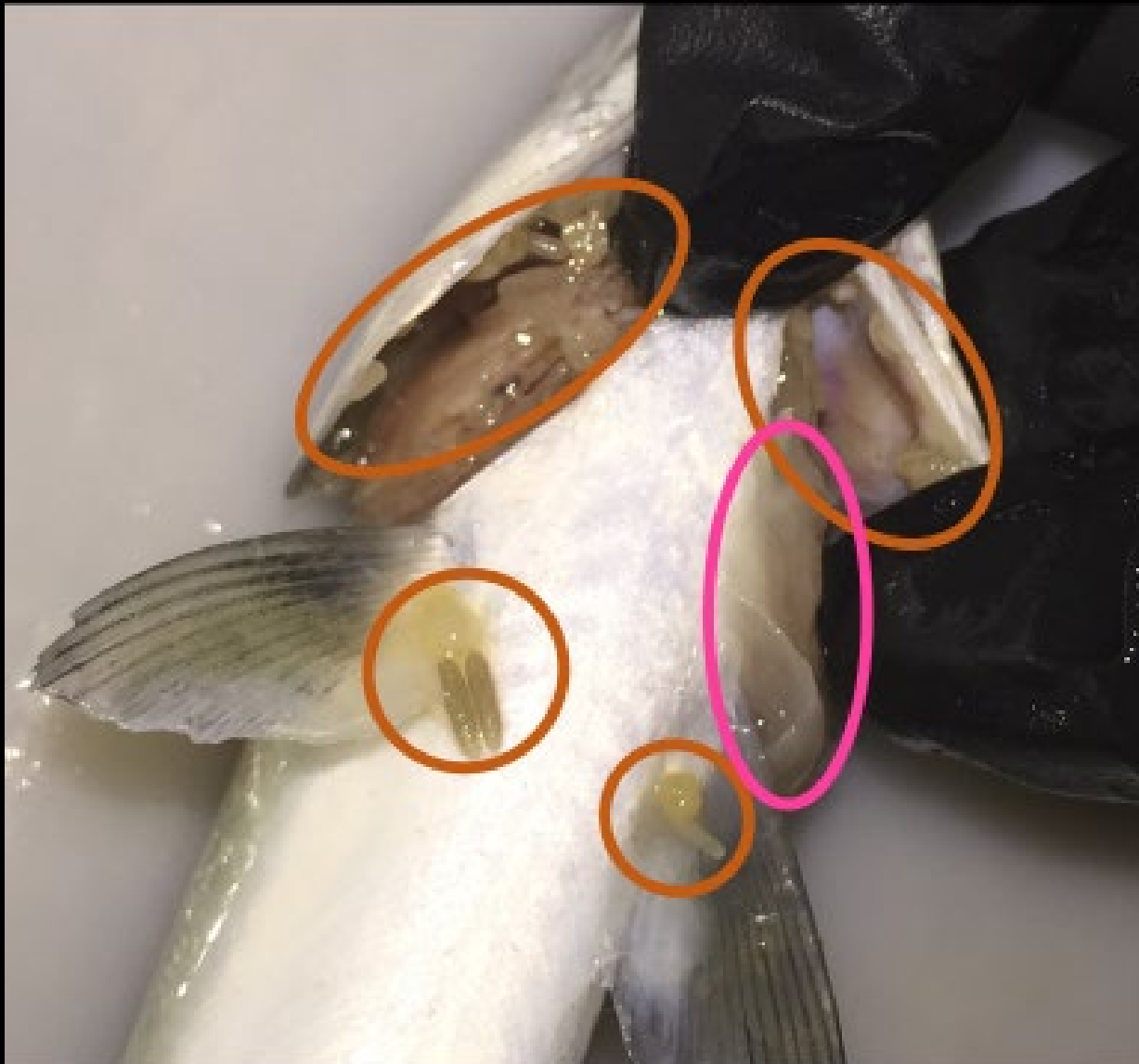


Have fish moved into trap or bypass  
because they are motivated,  
forced, passive, or sick ?

Different magnitude of effects  
but all bad



# Fish condition matters

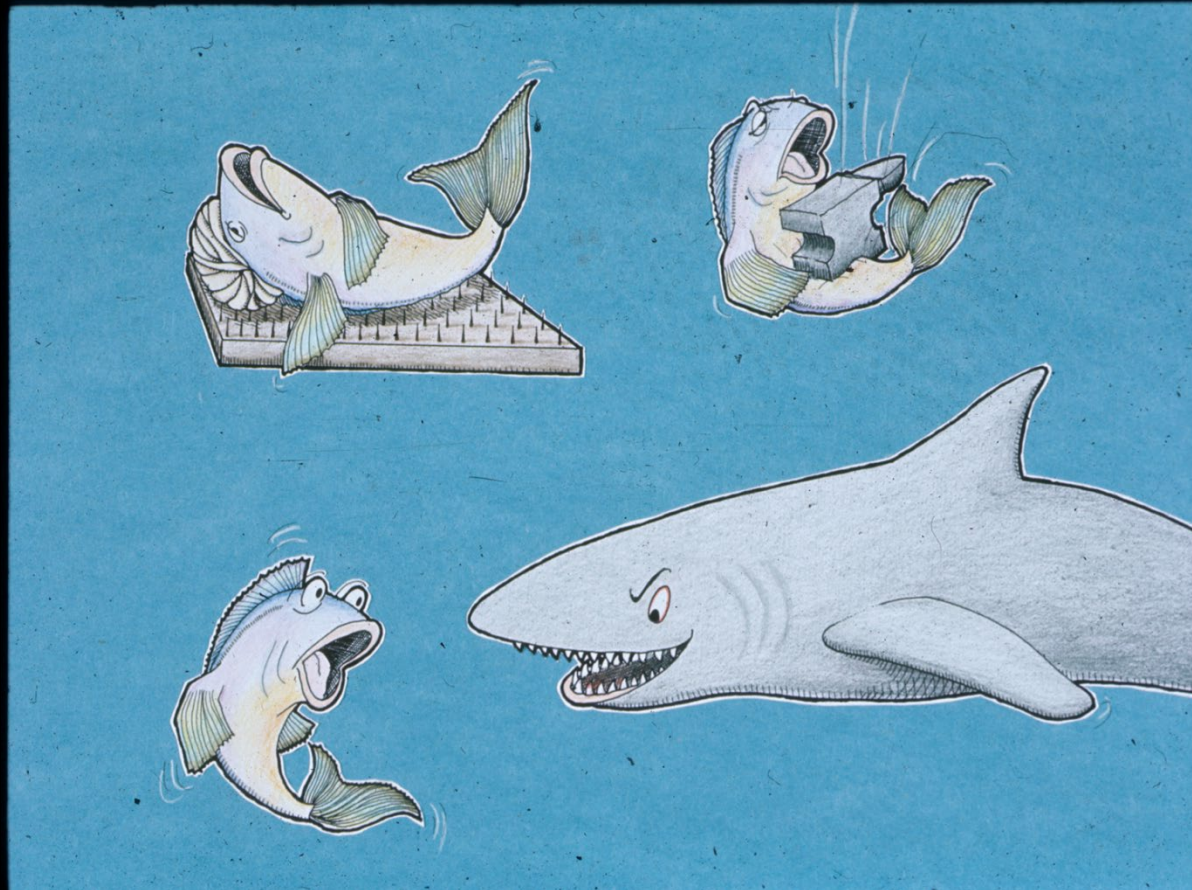


Herron

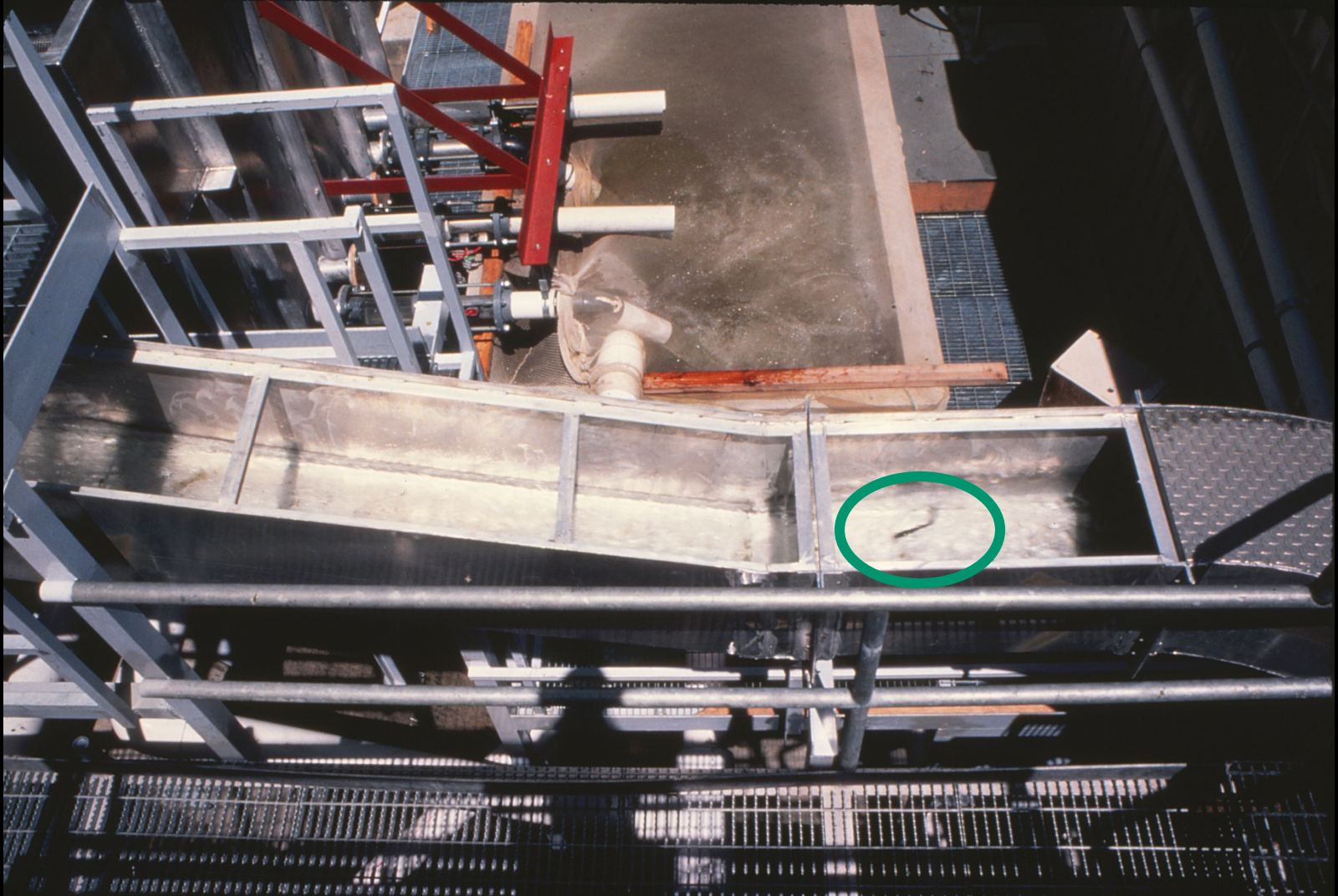
# Vectors



Stress above dam  
affects behavior/performance  
below



# Other trap & Haul or Bypass variables



# The transport vehicle & condition of fish pre-loading matters



# Trip duration matters



# The Species being Trap & Hauled matters

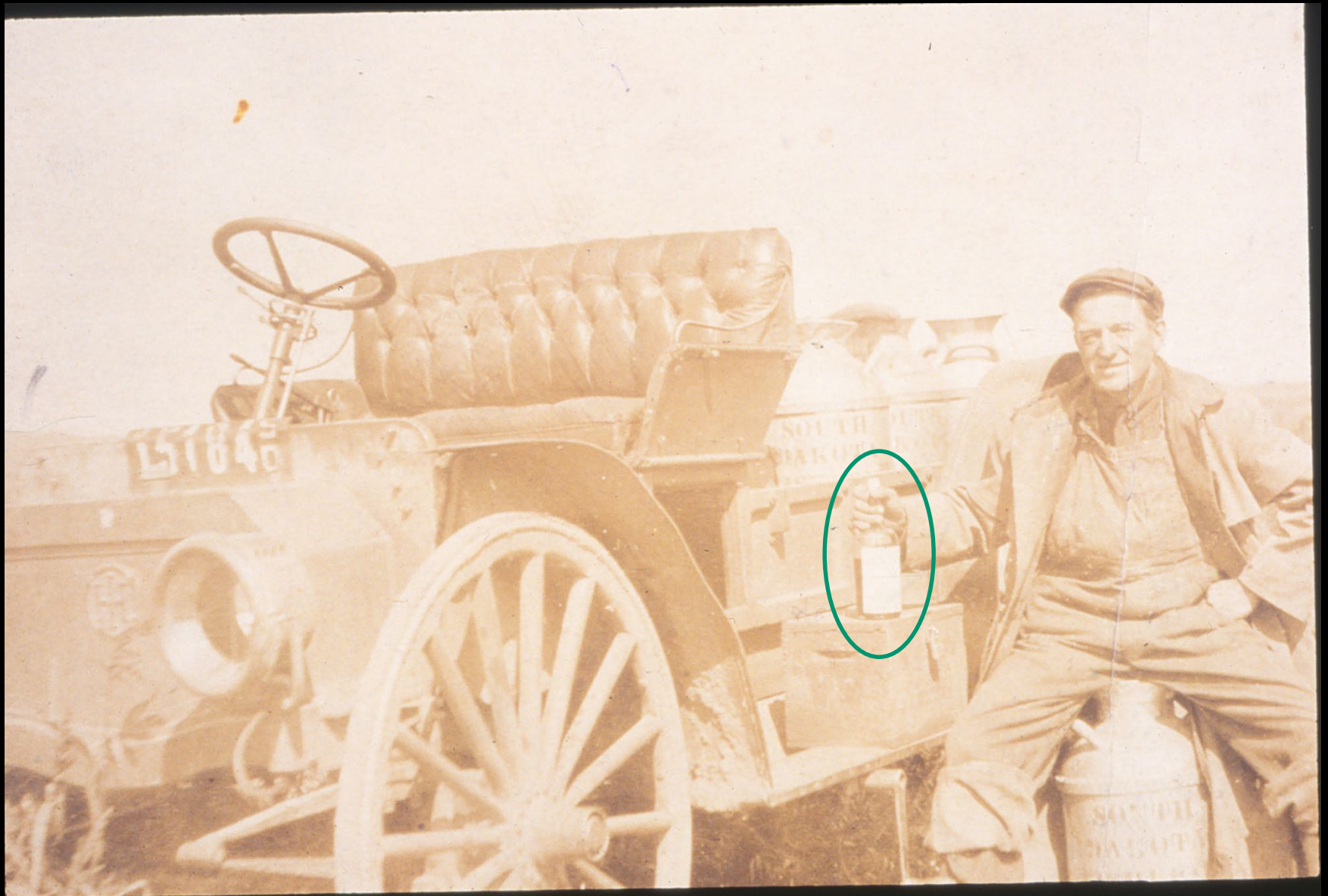
Chinook are stress-sensitive



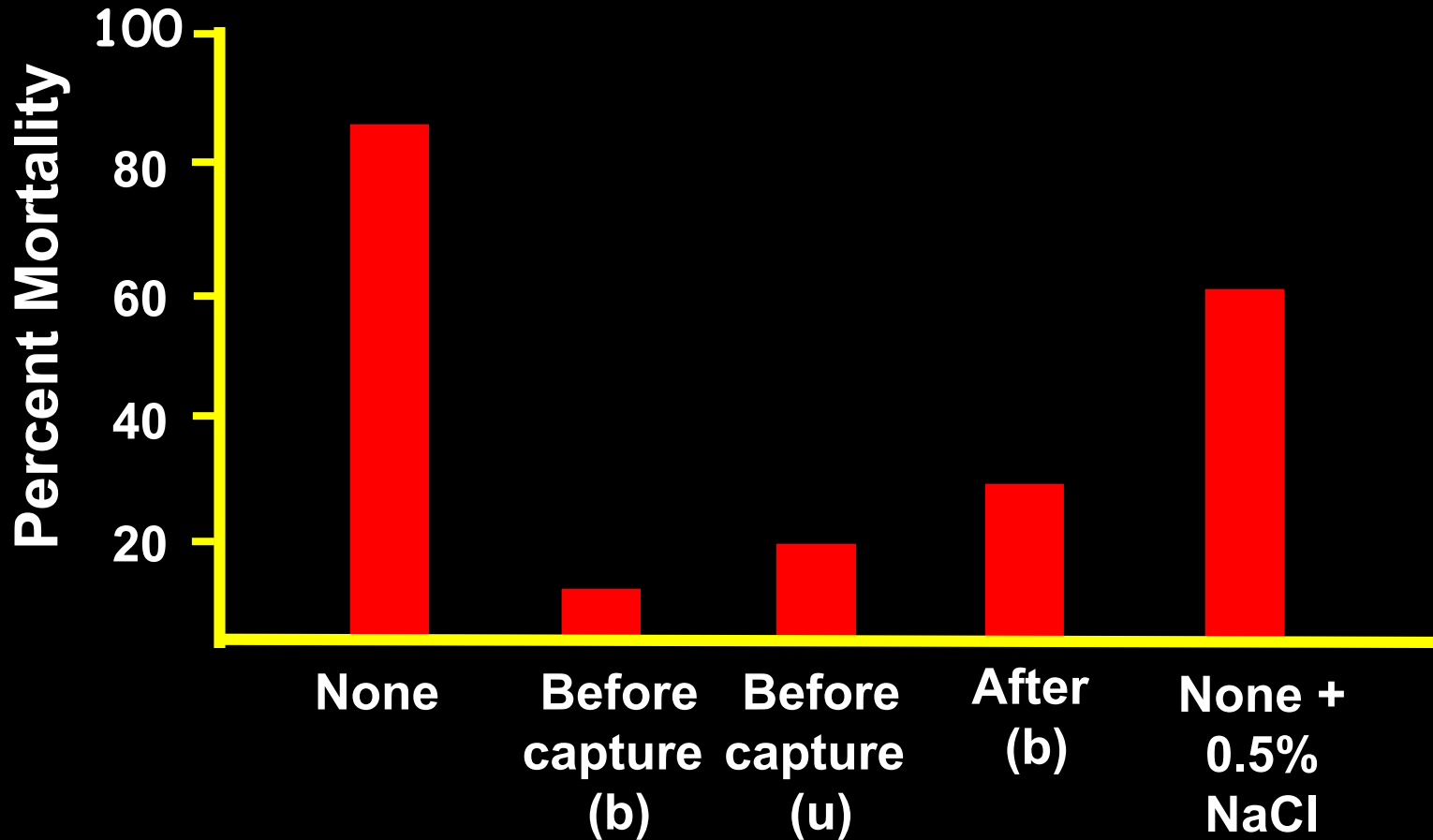


# Water quality critical

Transport medium additives?



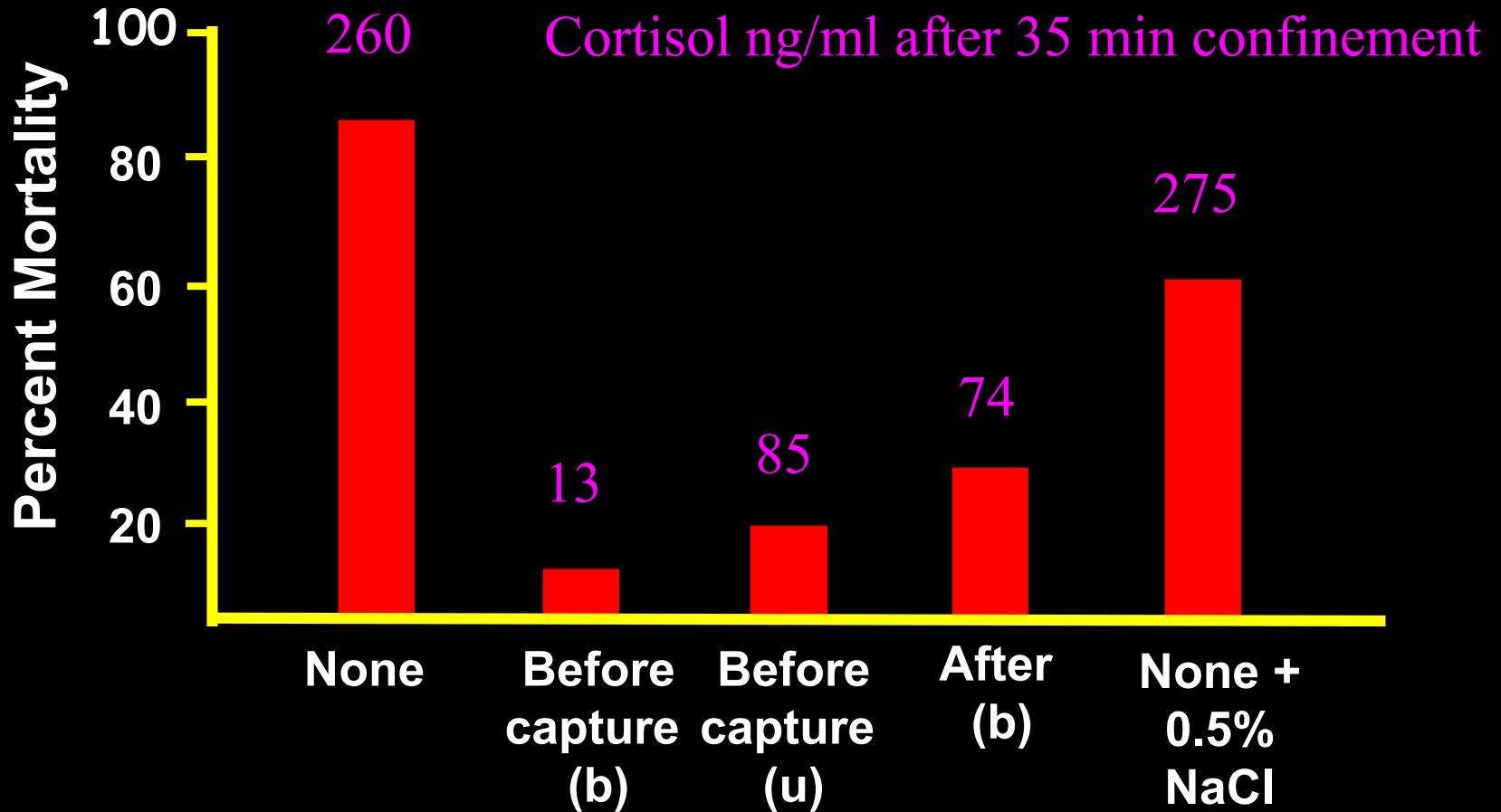
# Effect of Anesthetics on Capture and Crowding 24 hr



MS 222 Anesthetic Treatment

Strange & Schreck

# Effect of Anesthetics on Capture and Crowding 24 hr



MS 222 Anesthetic Treatment

Stress pheromones?



# Release matters: How & where



[http://www.nps.gov/romo/images/ig\\_stockfishglaciercreek1932\\_1.jpg](http://www.nps.gov/romo/images/ig_stockfishglaciercreek1932_1.jpg)



# Release stress & predation

## Day vs night release



Stress can result in disease, reduce predator avoidance, & affect other necessary functions

Particularly in smolts; e.g., BKD  
Cross infection & Immunosuppression





# The world according to Garp Carl: Important variables

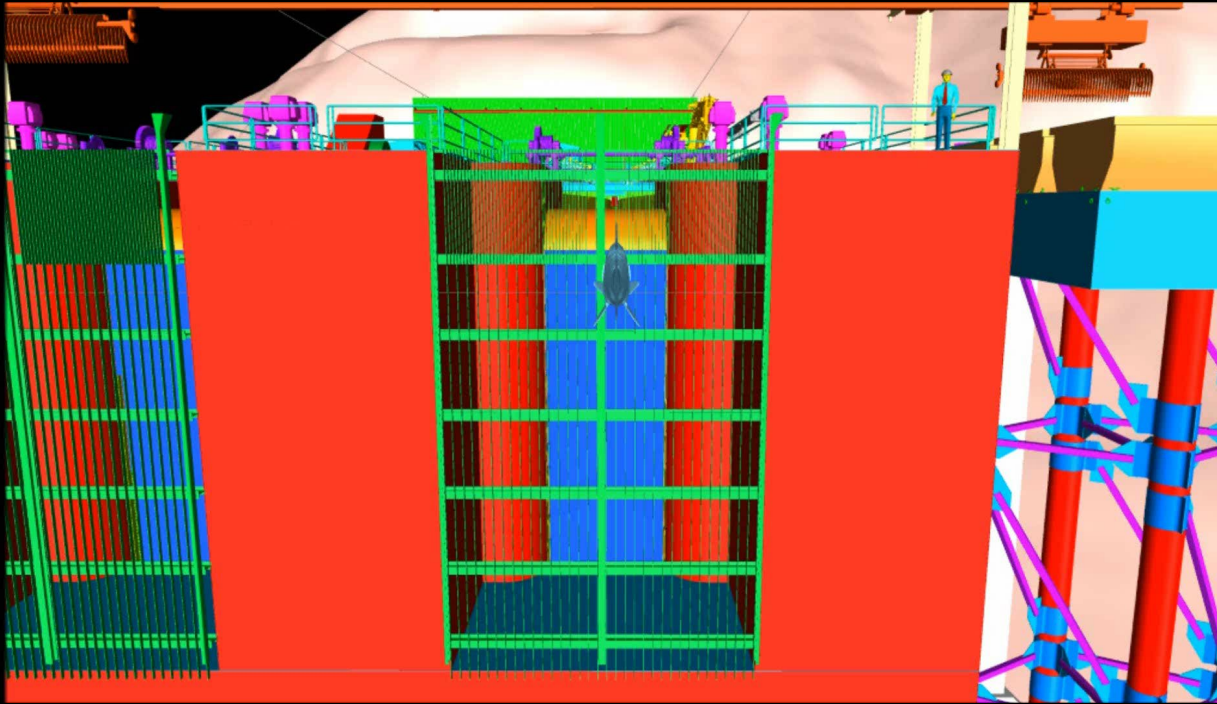
- Density/crowding
- Duration
- Temperature/other water quality
- Fish condition, developmental state
- Color of containers
- Light vs dark (better)
- Sound
- Other species present
- Recipient environment

# FINDING NEMO

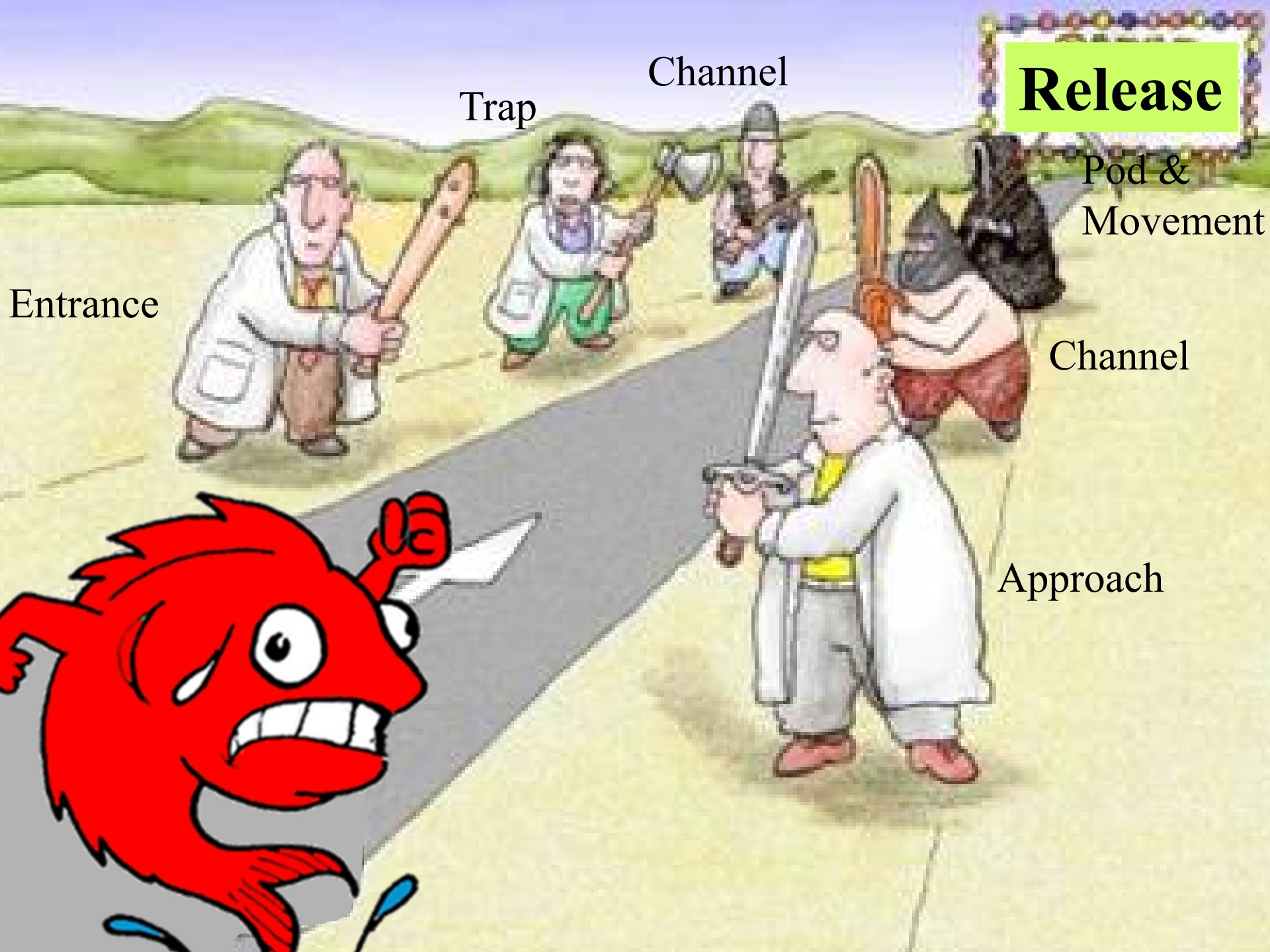


**Have to put all the parts together correctly. Any tactic that's not optimized is bad and effects cumulate**

# Detroit Trap & Haul Animation



Not a fisheye view



**Release**

Pod &  
Movement

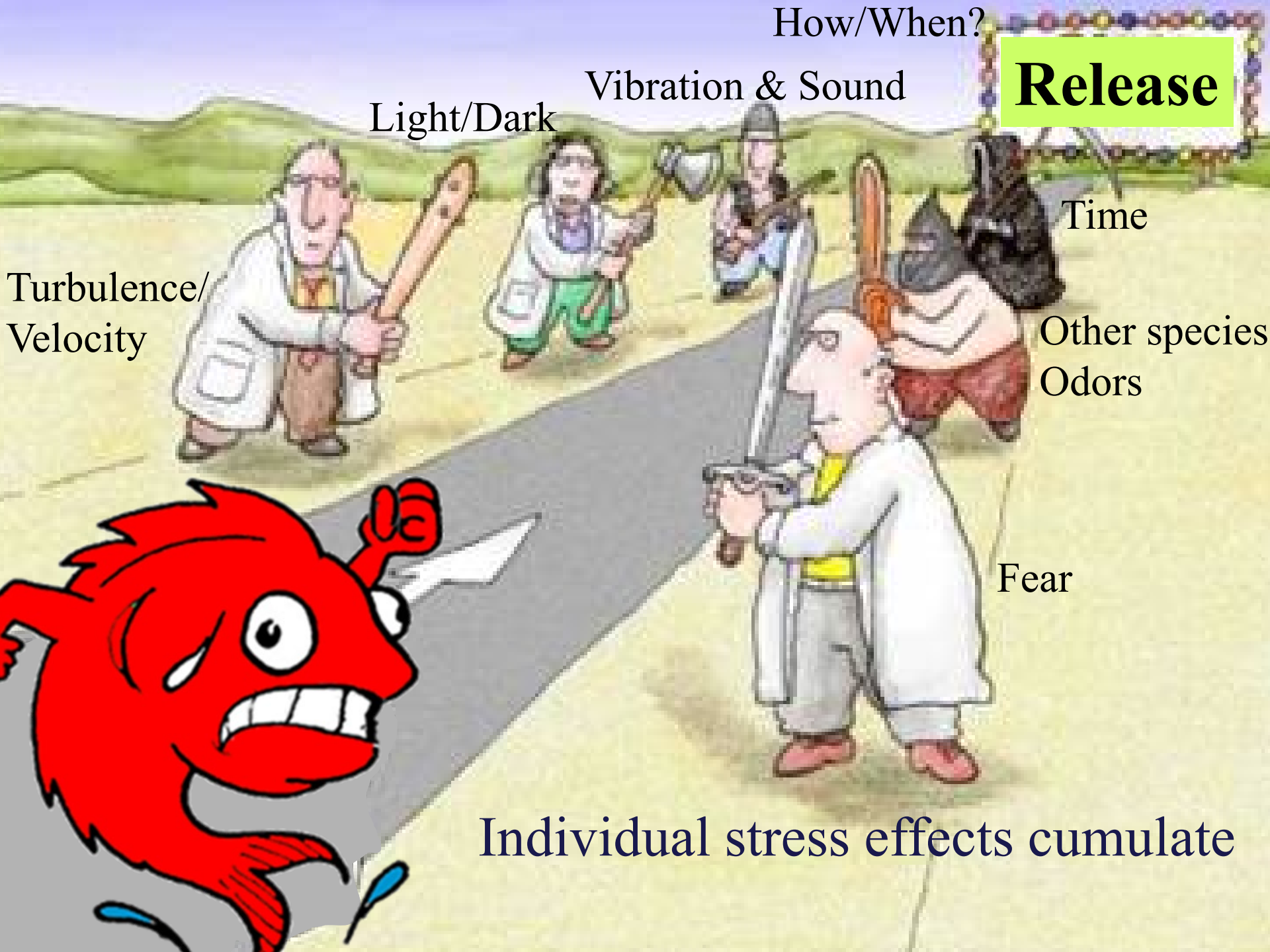
Channel

Approach

Channel

Trap

Entrance



How/When?

**Release**

Vibration & Sound

Light/Dark

Time

Other species

Odors

Fear

Turbulence/  
Velocity

Individual stress effects cumulate



### Trap and Haul –

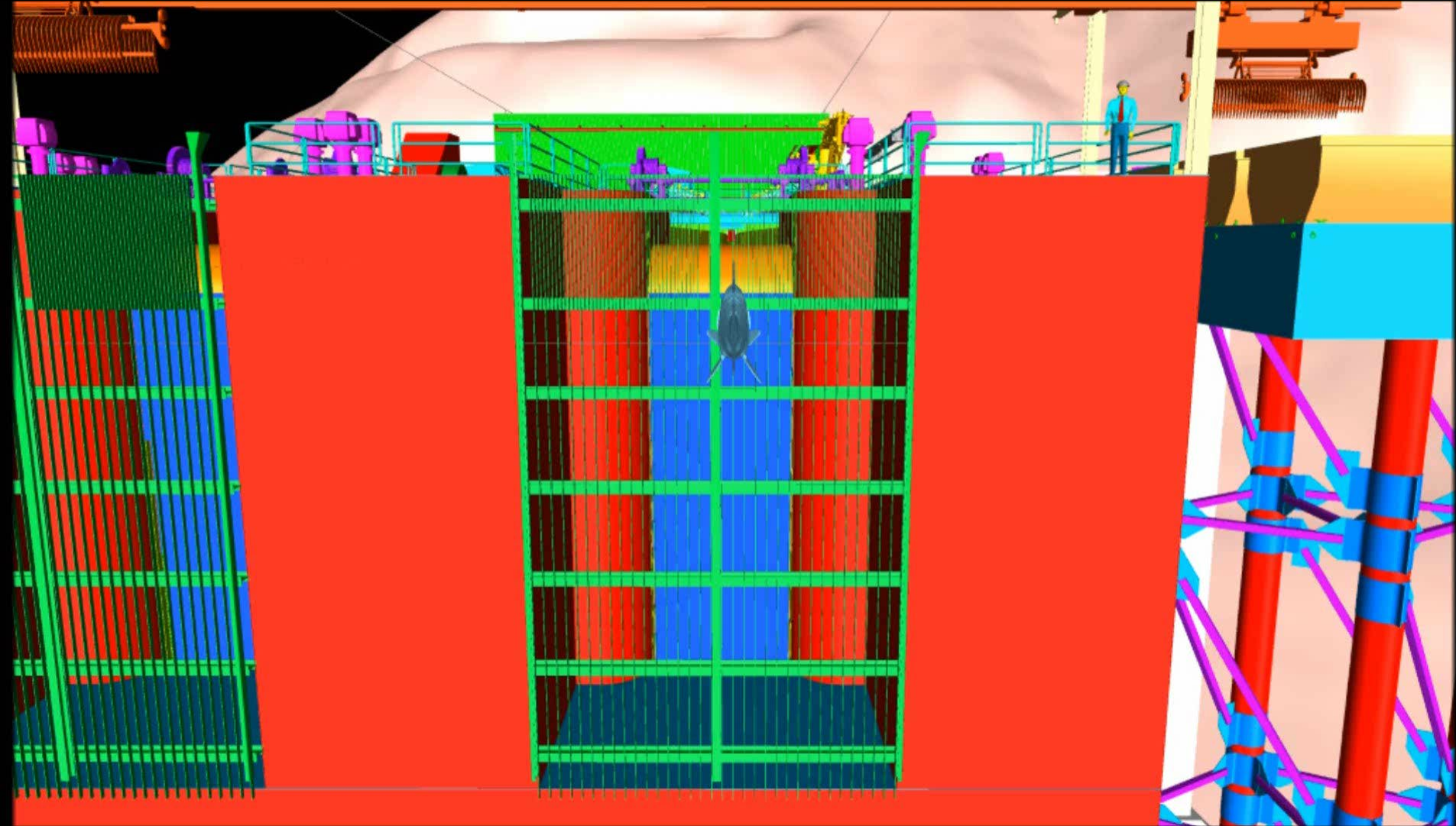
Entry + entrainment (capture velocity) + sorting/sampling + pod collection (captive) + crowding + multispecies interaction + lateral disease/parasite transmission + holding time + loading of pod onto amphibious vehicle + transport to release site + large group release = **STRESS!**

### Volitional Passage –

Entry + entrainment (capture velocity) + transport tube + subsampling (~10% as at Clackamas) + real time release = stress

Bottom Line: Bypass is  
desirable to trap & haul

Trap and haul tactics can be assessed in the lab,  
very difficult to do with bypass



Detroit Trap & Haul animation



# Fish condition matters: Re Copepods

- Cougar, natural infection trap & ~ 2-3 hr Haul
  - 34 dead out of 40 by 5 days
- Lab infected, netting & bucket transfer ~20 sec
  - 2 dead out of 40 in 2 days, 0 uninfected dead
- Lab infected, netting & bucket transfer ~20 sec
  - 2 dead out of 63 in 2 days, 0 uninfected dead
- Lab infected, netting & IP injection ~ 1 min
  - 30 dead out of 30 in 10 days, 0 uninfected dead