Electroshock Effects on Fish

Tab 10

Session Objectives

(Page 10-1)

familiarize folks with typical reactions of fish in electric fields generated by various waveforms

increase awareness of fish trama issues

discuss methods of minimizing the potential for fish trama

A. Two Categories of Electroshock Effects

Behavior (or reactive movements)

Trama (stress and injury)

Behavior

Reactions; e.g., fright, taxis

Use of certain responses for capture or control

Trauma

- Stress is usually physiological (no mechanical injury)
  - recovery short-term
- Injury is mechanical
  - recovery long-term

B. Fish Behavior in Electrical Fields

Common Terms

(Page 10-1,2)

Threshold: the minimum level of a stimulus (e.g., power density) to achieve some response

Taxis or Electrotaxis: electrically-induced movement (usually toward the anode)

Narcosis: a state of electrically-induced immobility with slack muscles

Common Terms (continued)

Tetany: a state of electrically-induced immobility with rigid muscles

False taxis or pseudo-forced swimming: as electrotaxis except that the fish is unconscious and usually belly-up

Oscillotaxis: electrically-induced movement without orientation

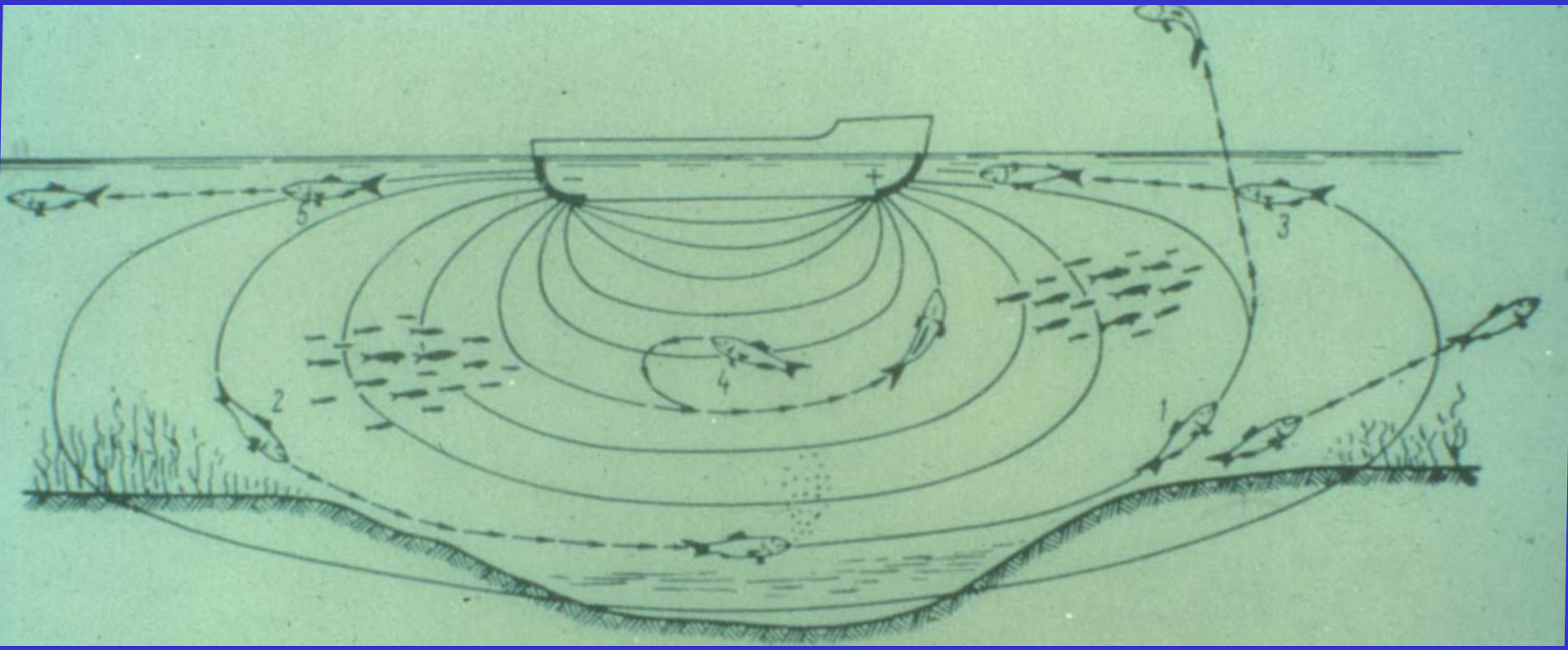
For Practical Use in Field

- Escape (upright avoidance swimming)
- Inhibited swimming (unbalanced swimming)
- Immobilization (no swimming motions)

Inhibited swimming includes taxis

Immobilization includes narcosis & tetany

Behavior in Electric Fields



From an illustration in Sternin et al. (1972)

Fish Response to AC

- Inhibited swimming

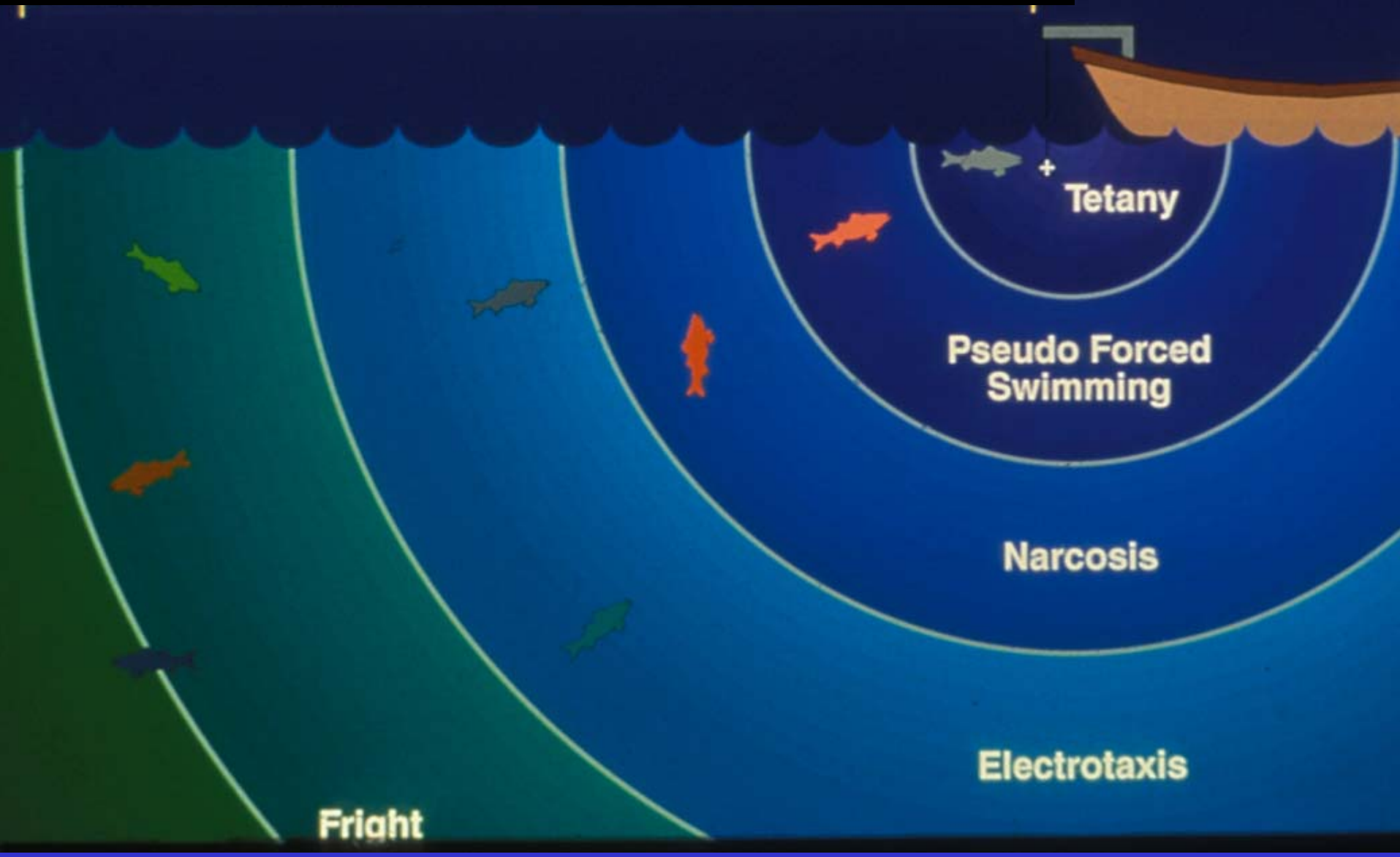
↓

- Transverse oscillotaxis

↓

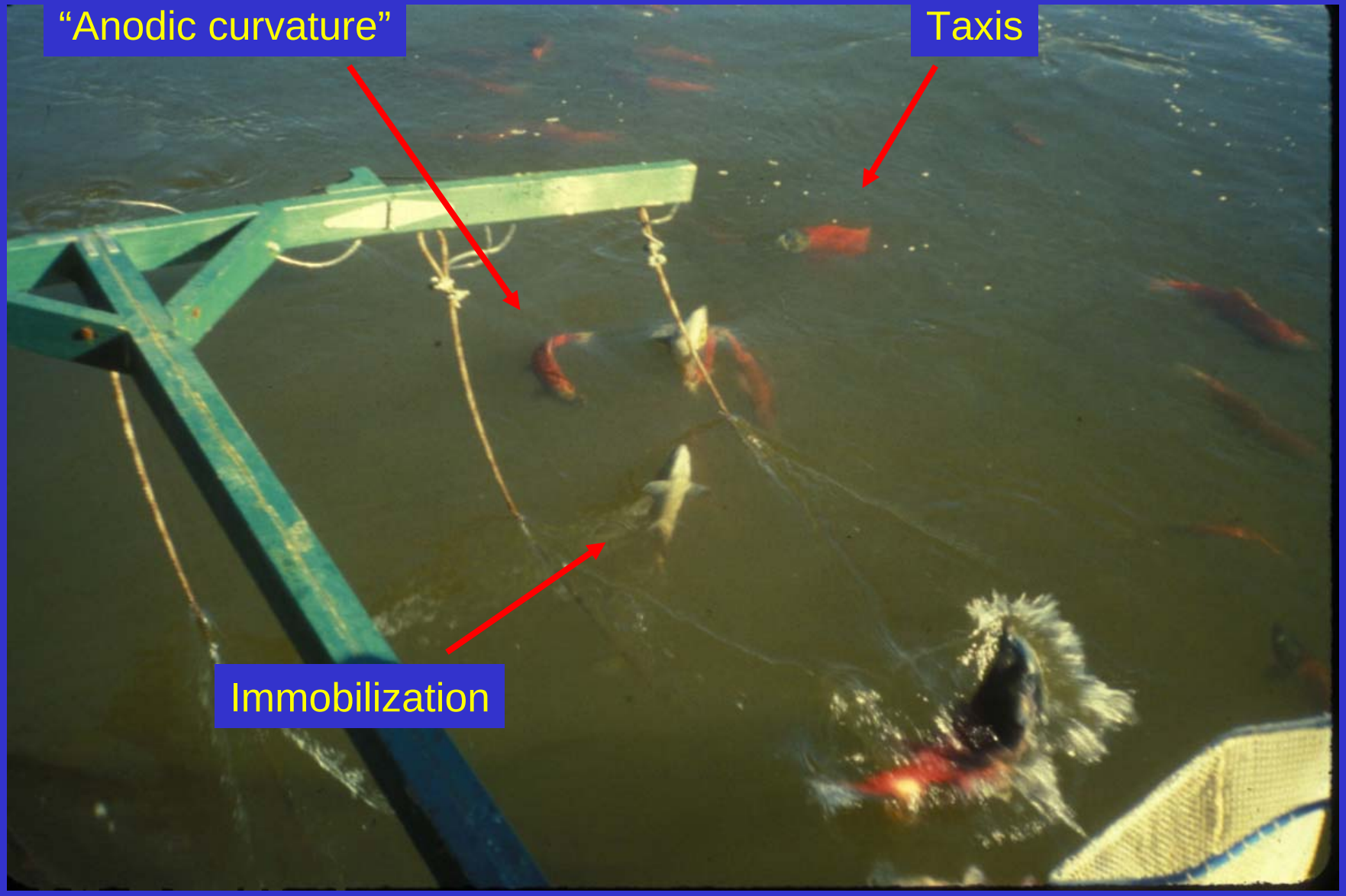
- Tetany

Fish Response to DC



“Immobilization”: tetany or narcosis

Fish Response to DC



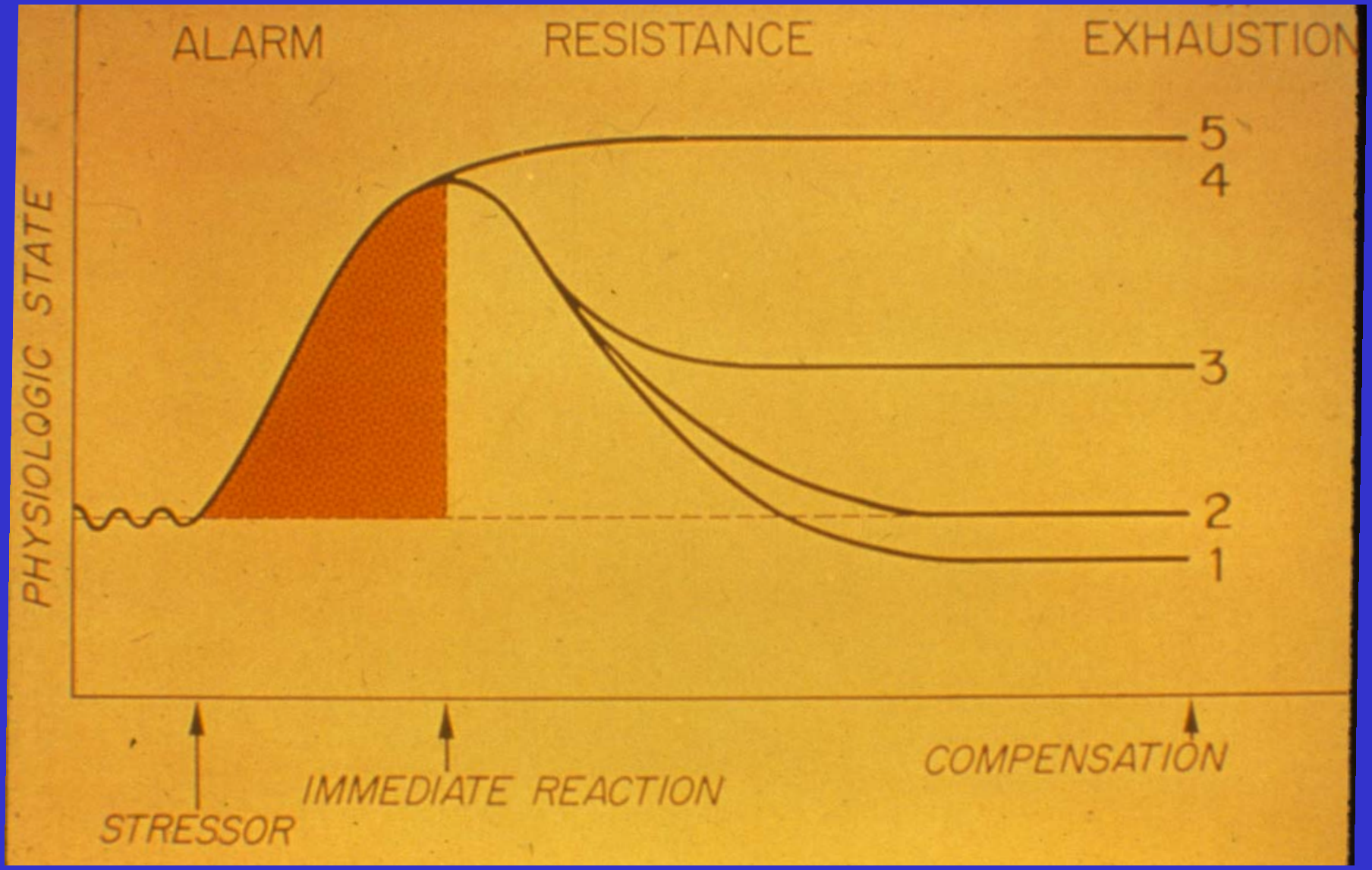
Fish Response to Pulsed DC

- May or may not cause taxis
  - Taxis response observed (for brown trout, *Salmo trutta)*
  - Taxis response not observed (for goldfish, *Carassius auratus*)
  - Lamarque concluded from lab experiments that PDC has poorer anodic taxis as compared to DC
- Complicated because of the many different types of PDC waveforms
- May be somewhat intermediate between AC & DC responses (can have taxis, narcosis, and tetany responses)

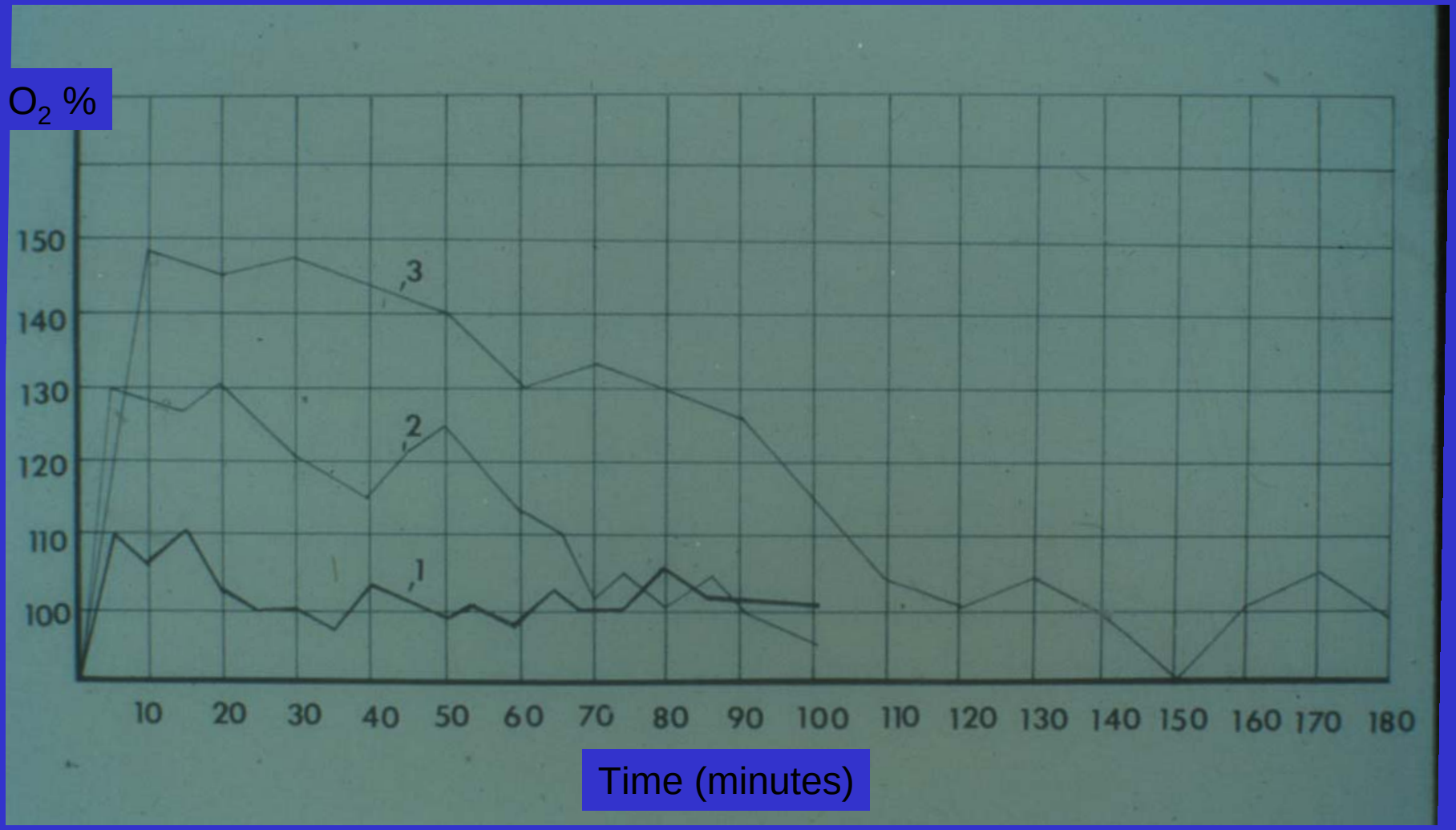
Quiz Question
(Tetany or Narcosis?)

- Narcosis
  - gentle curvature of body
  - Absence of “flared gills” (a characteristic of tetany)

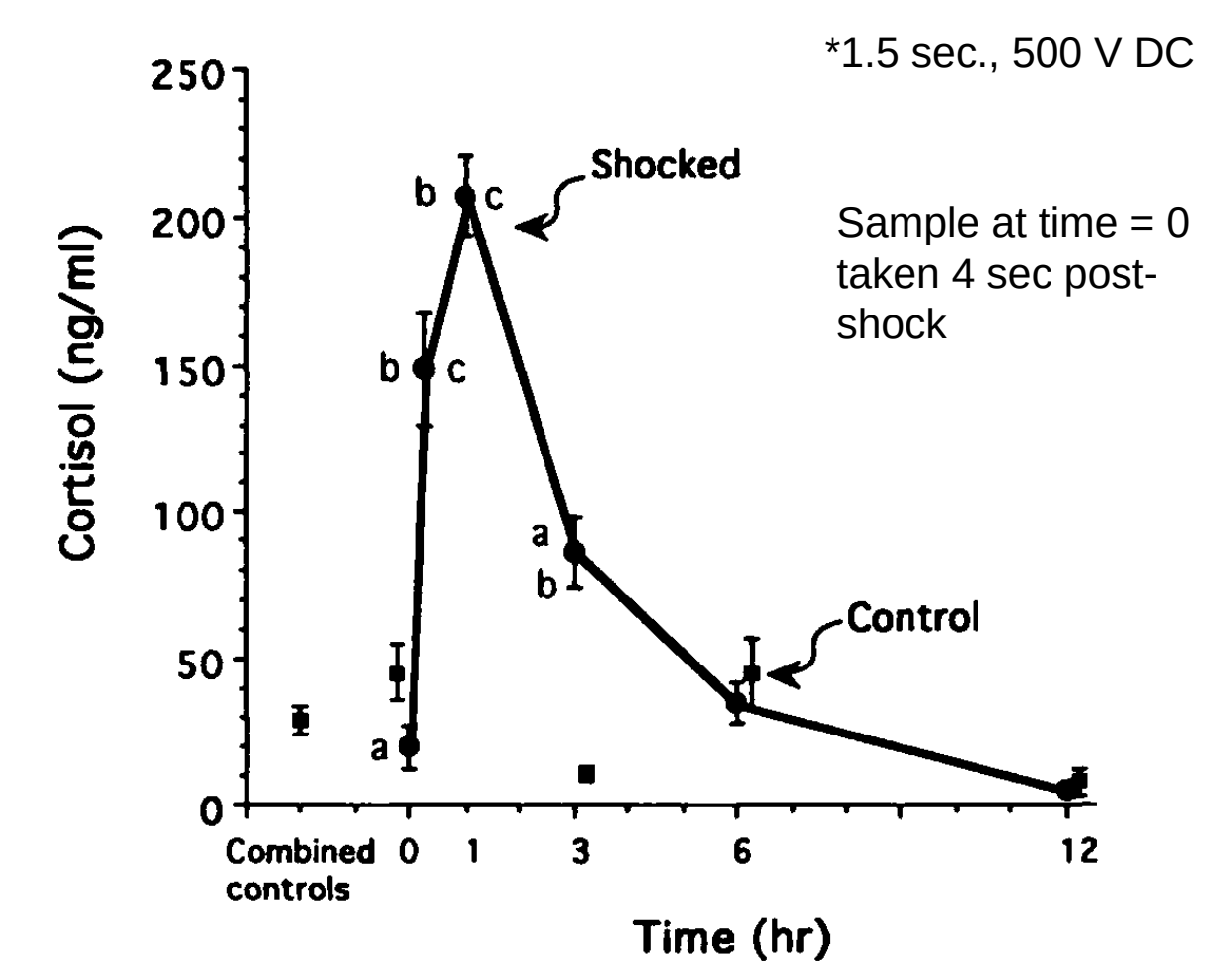
Trauma
General Stress Response Model



Lab Example Using DC (1), PDC (2), AC (3)

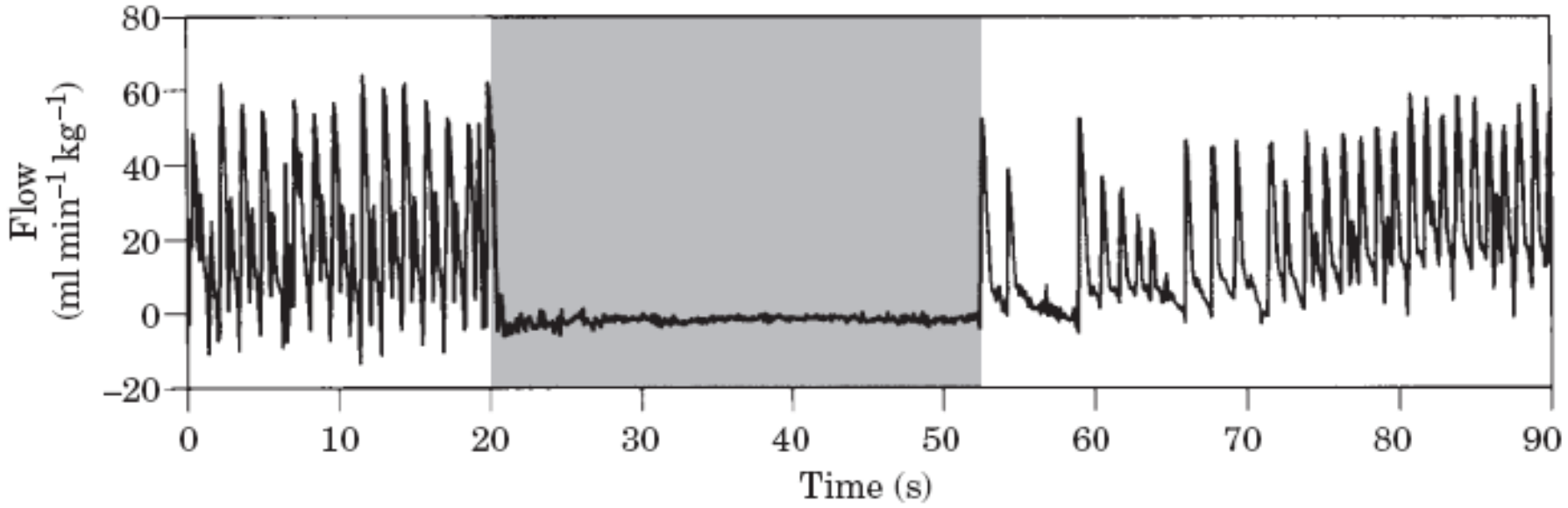


Plasma Cortisol in Fall Chinook Salmon



"a" = shocked mean different from control mean at that time
"b" =shocked mean different from mean of all controls
"c" =shocked mean different from shocked mean at time 0

Rainbow Trout EKG



Waveform applied: PDC, 100 V, 30 Hz, 2 ms pulse width for 32 sec

Shaded area: electrical power on

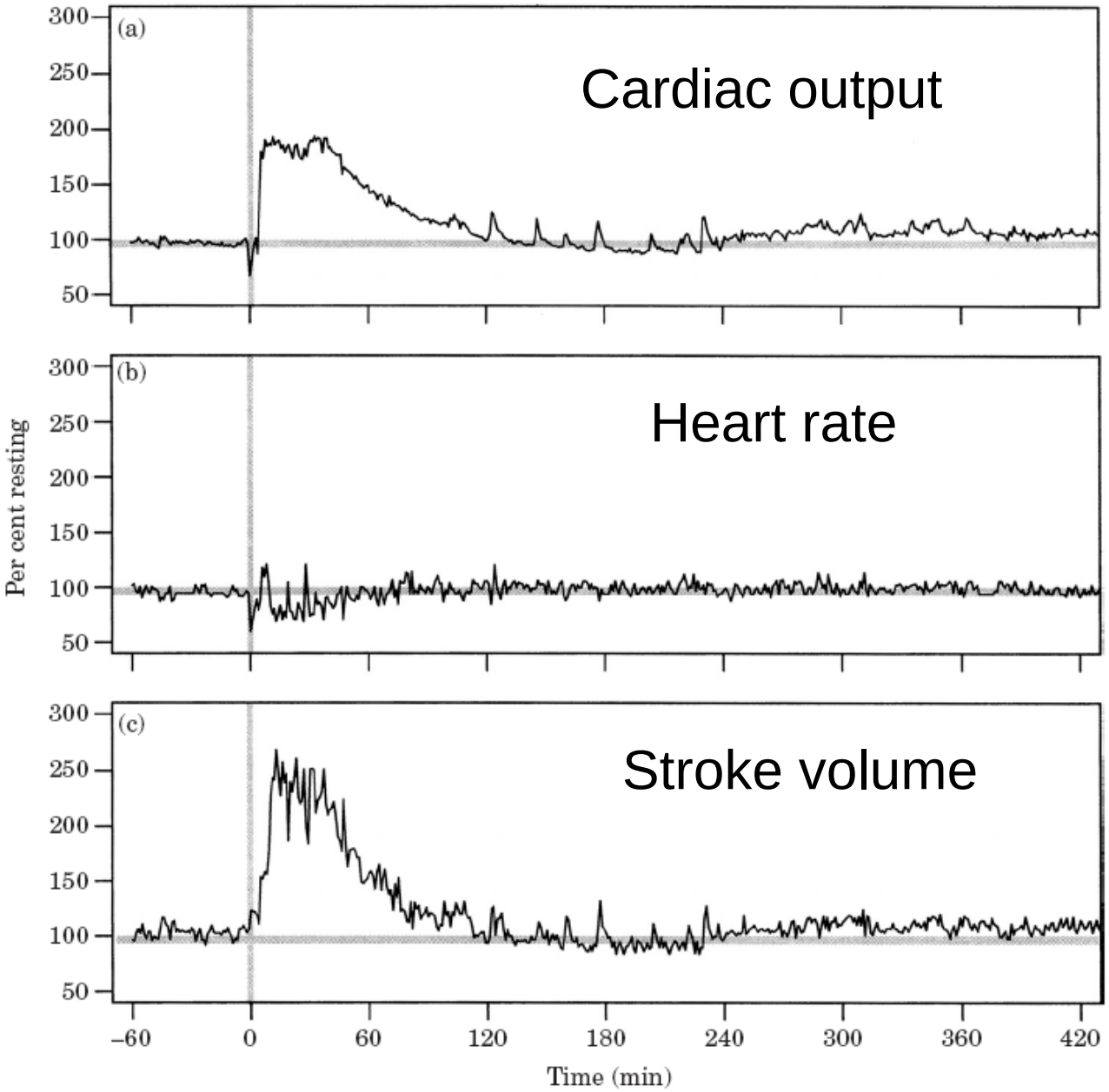
Schreer et al. (2004)

Rainbow Trout EKG

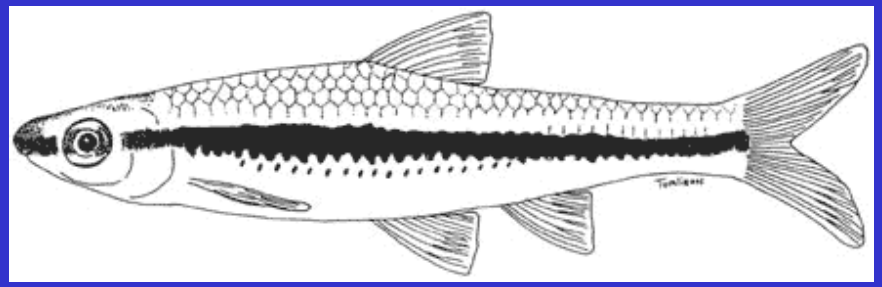
Waveform used:
100 V, 80 – 8 Hz,
2 ms, for 8 sec

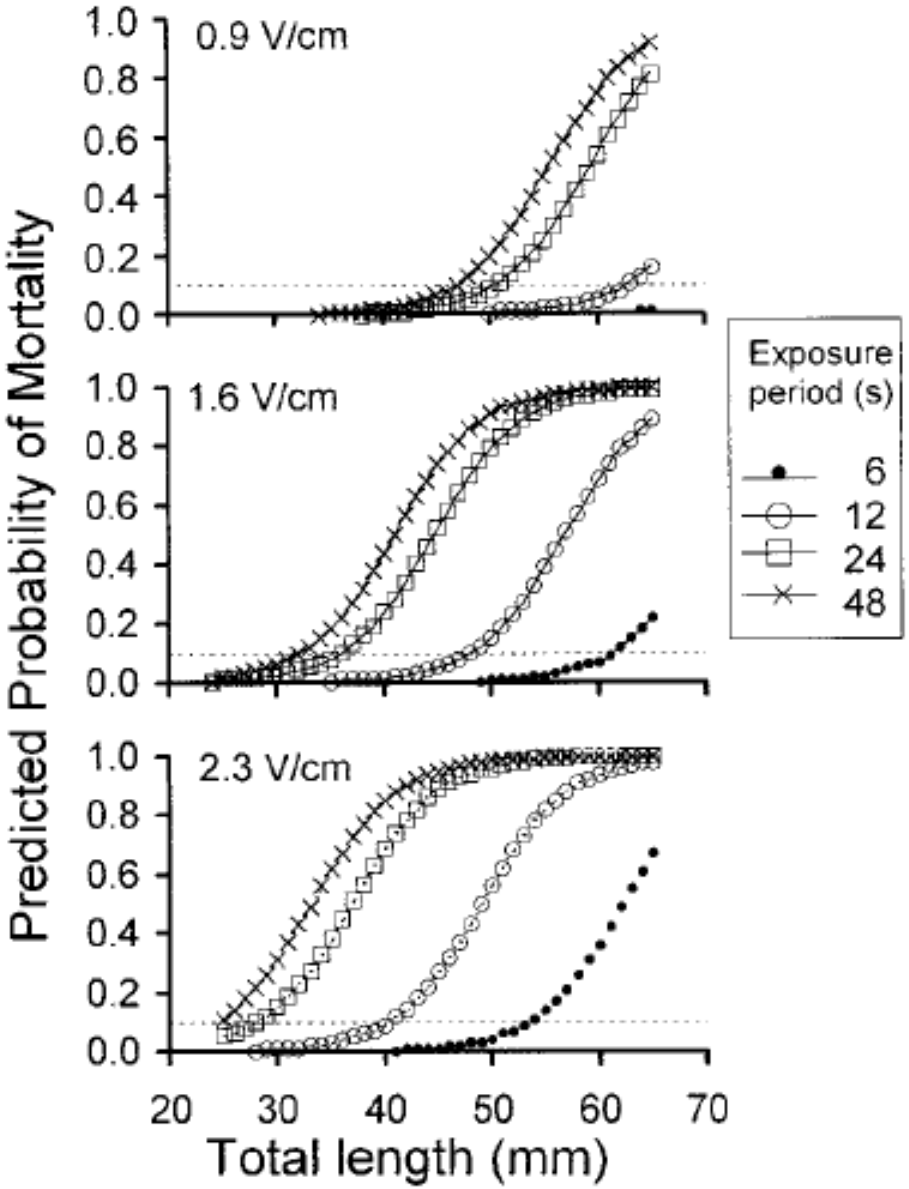
Found that longer shock durations increased the duration of cardiac arrest & recovery

Vertical shaded bars: electrical power on



Predicted Probability of Mortality for Cape Fear Shiners Exposed to 60 Hz PDC





No injures (vertebrae fractures or hemorrhages) were detected

Holliman et al. (2003)

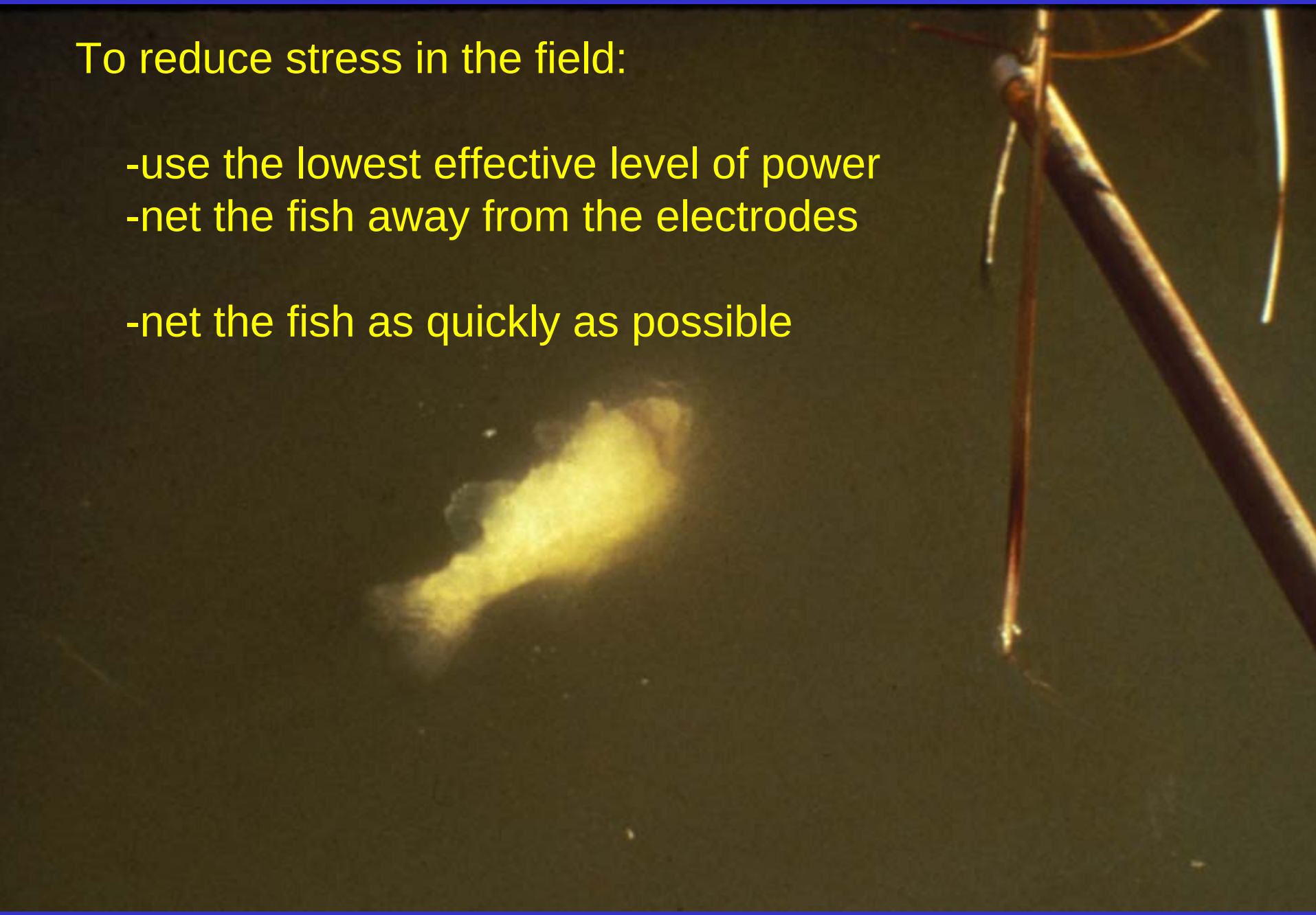
Stress-related Effects of EF

- Smaller fish usually do not have a high incidence of injuries (< 10%) but are susceptible to stress
- Stress-related physiological changes are typically short-term (3 – 6 hours)
- Related behavioral effects (e.g., reduce feeding or predator avoidance also may be typically short-term)
- Mortality can occur with smaller fish due to stress and increases with…
  - Field intensity (voltage gradient, power density)
  - Duration of exposure
  - Length of fish

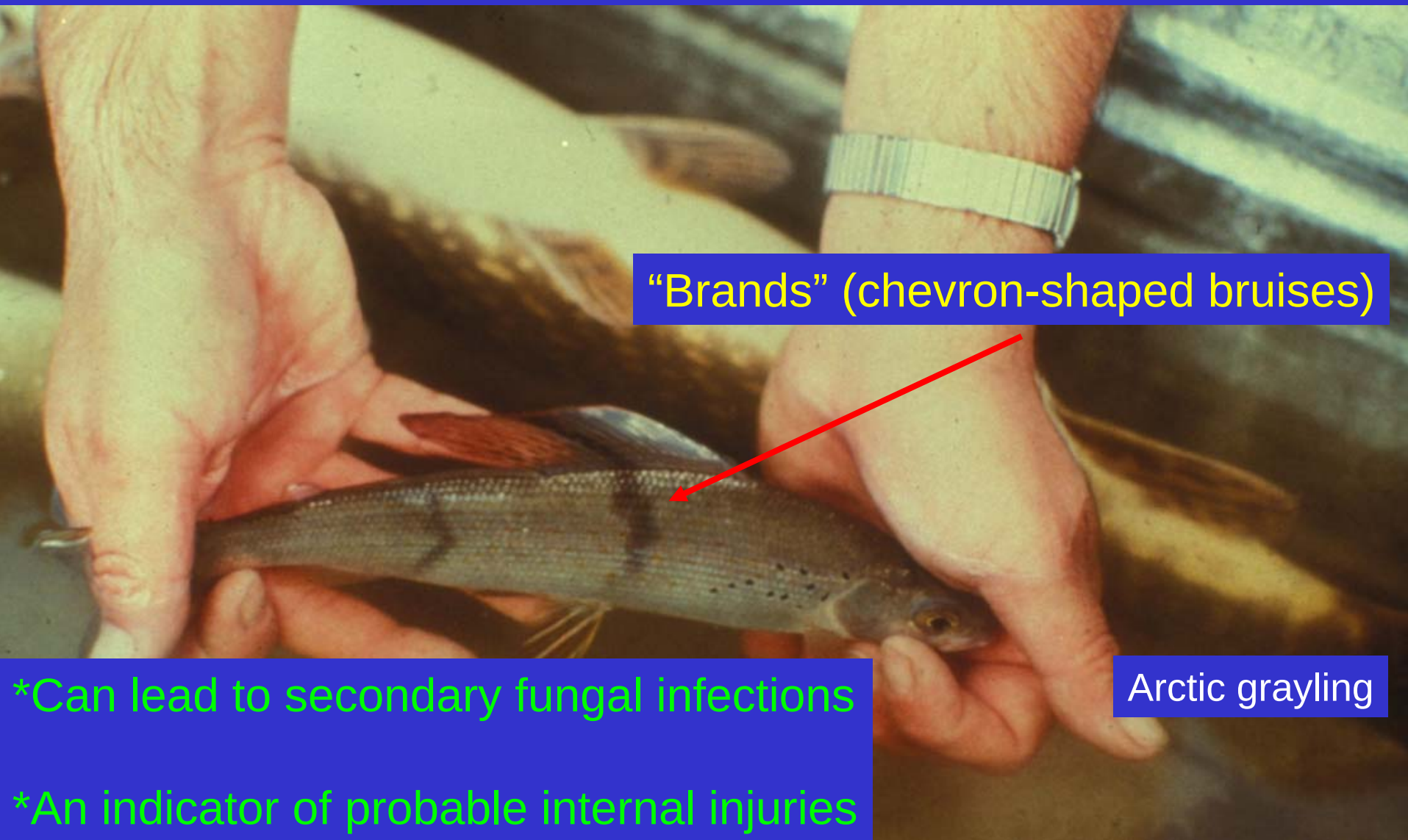
To reduce stress in the field:

-use the lowest effective level of power
-net the fish away from the electrodes

-net the fish as quickly as possible



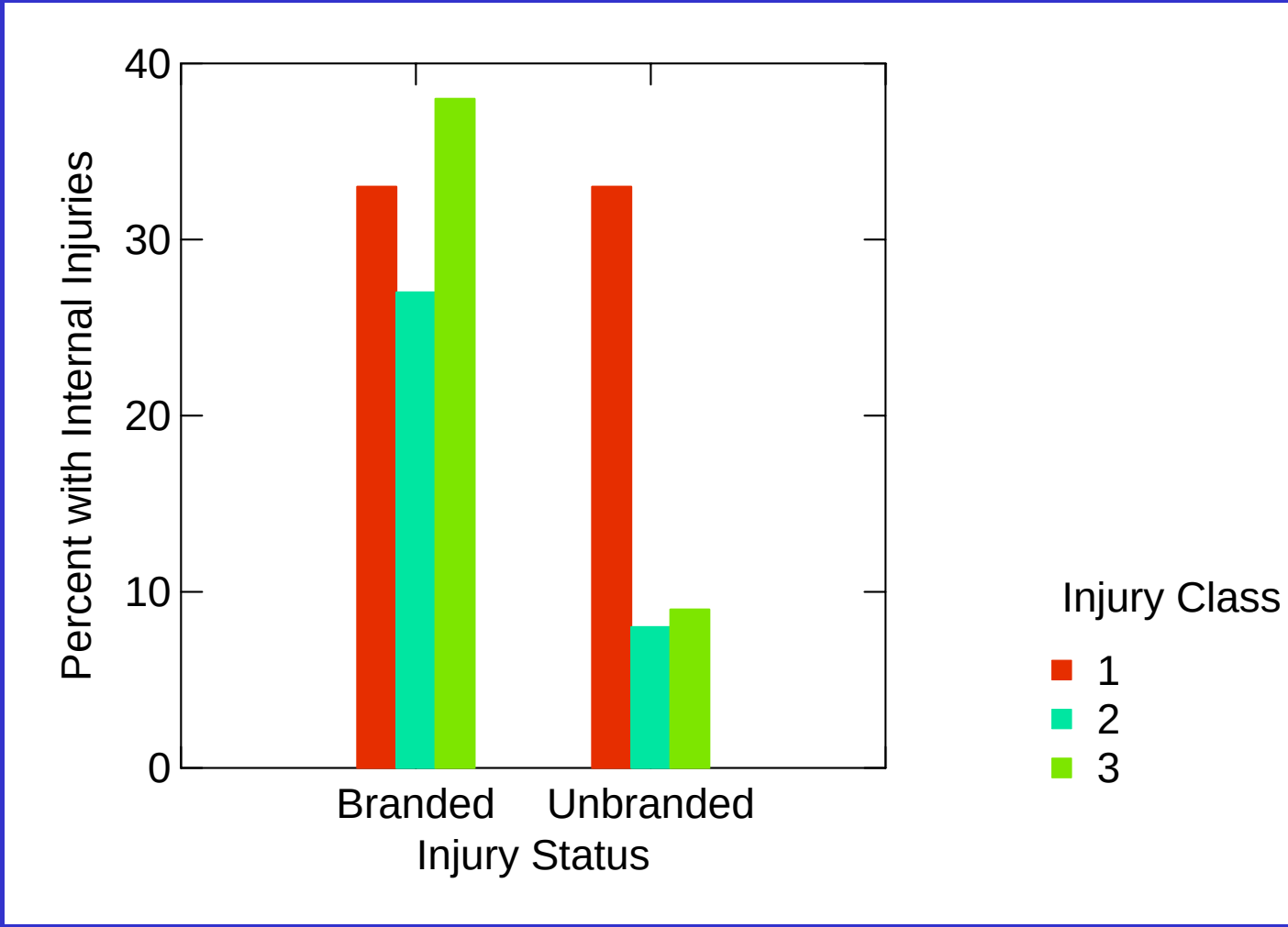
Trauma- Injury (external)



*Can lead to secondary fungal infections

*An indicator of probable internal injuries

Trauma- Injury (external)



If brands present, higher likelihood of more severe, internal injuries

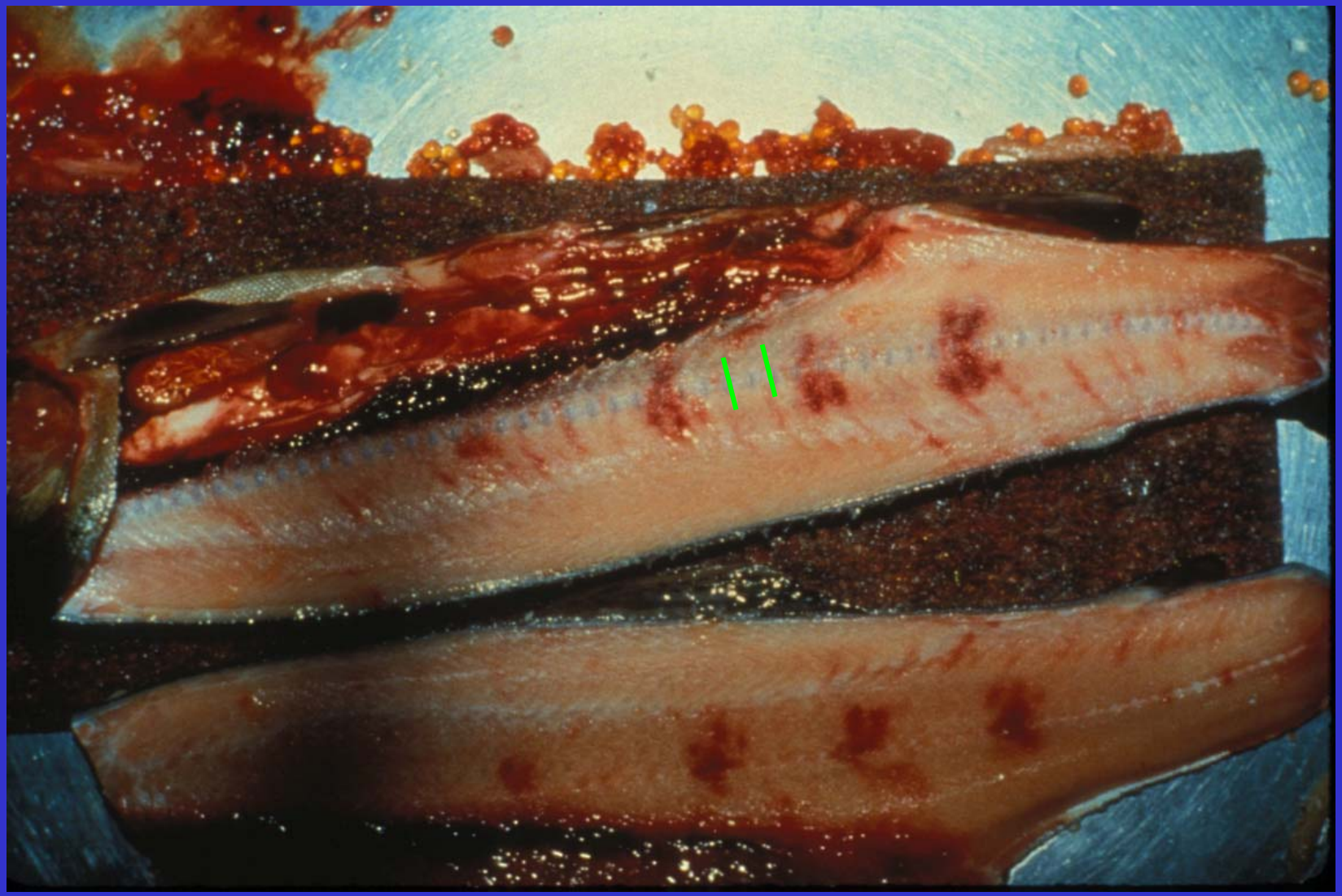
Injury severity increases from class 1 to class 3

Trauma- Injury (internal)

Internal Hemorrhage Classification System
(Page 10 – 10)

Class	Description
0	No hemorrhage present
1	Mild hemorrhage; one or more wounds in muscle, separate from the spine
2	Moderate hemorrhage; one or more small (≤ width 2 vertebrae) wounds on spine
3	Severe hemorrhage; one or more large (> width 2 vertebrae) wounds on spine

Internal Hemorrhage Classification



Can be frozen before filleting

Blood from filleting process easily wipes off; hemorrhages do not

Guidelines for Assessment and Reduction of EF-induced Injuries…

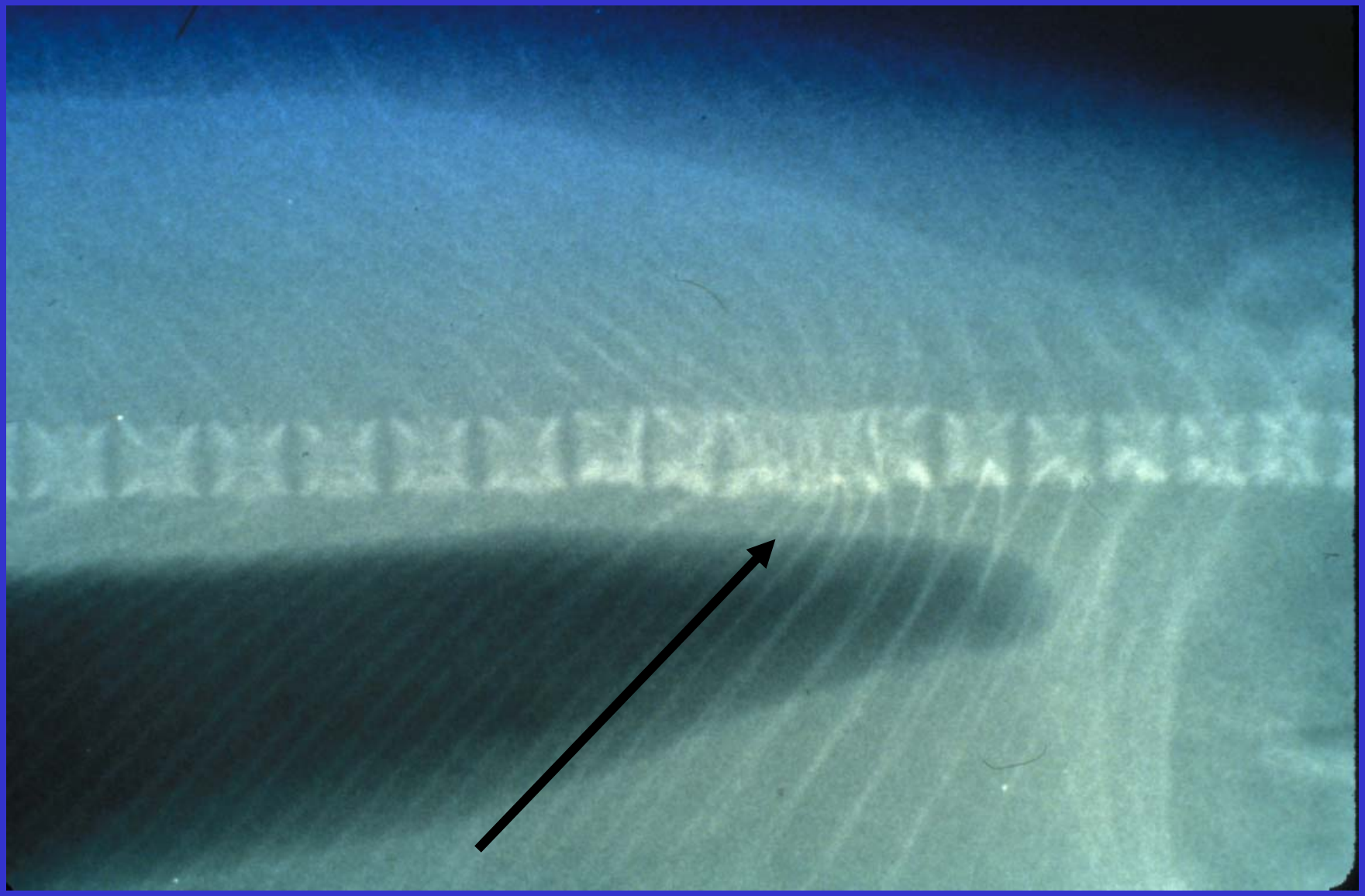
- Page 6 (Reynolds & Holliman paper in Tab 10)
- Collect 20 similar-sized individuals of larger size category
- Fillet
- Calculate proportion of injured fish
- If hemorrhage proportion low, then spinal injury likely unimportant; otherwise, take x-rays of another sample of 20 fish to assess proportion with spinal injuries

Trauma- Injury (internal)

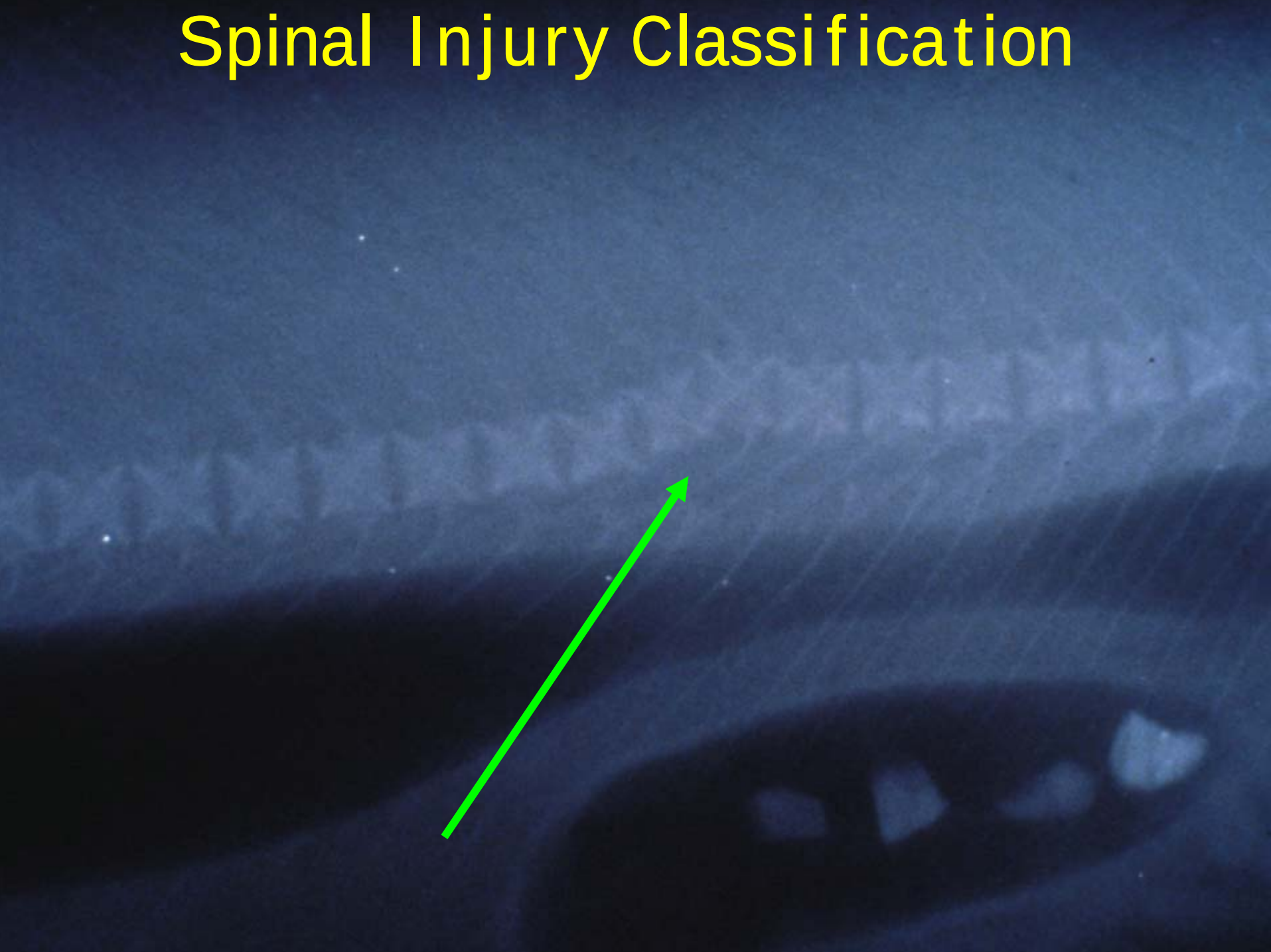
Spinal Damage Classification System
(Page 10 – 10)

Class	Description
0	No spinal damage present
1	Compression (distortion) of vertebrae only
2	Misalignment of vertebrae, including compression
3	Fracture of ≥ 1 vertebrae or complete separation of ≥ 2 vertebrae

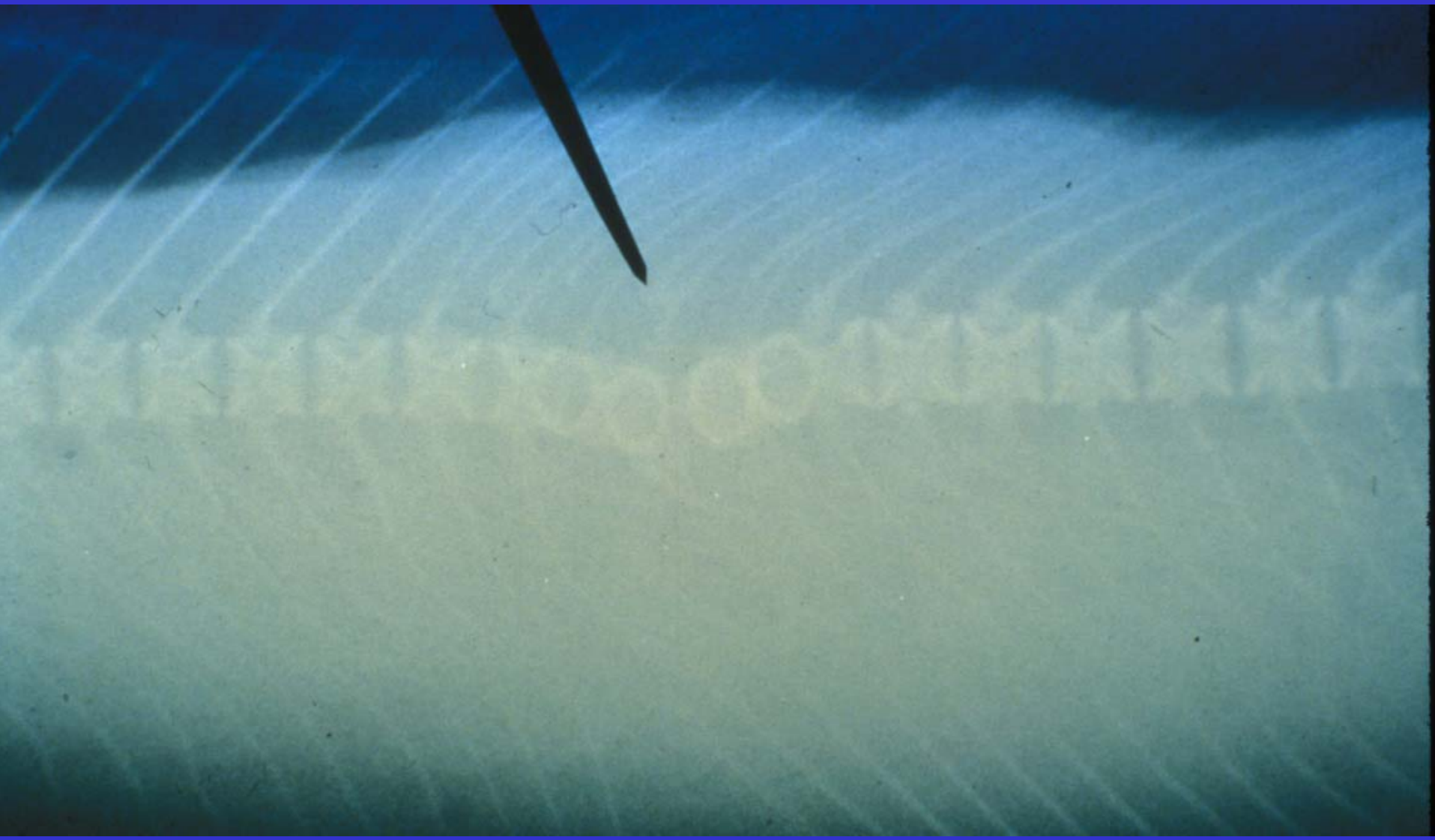
Spinal Injury Classification



Spinal Injury Classification



Spinal Injury Classification



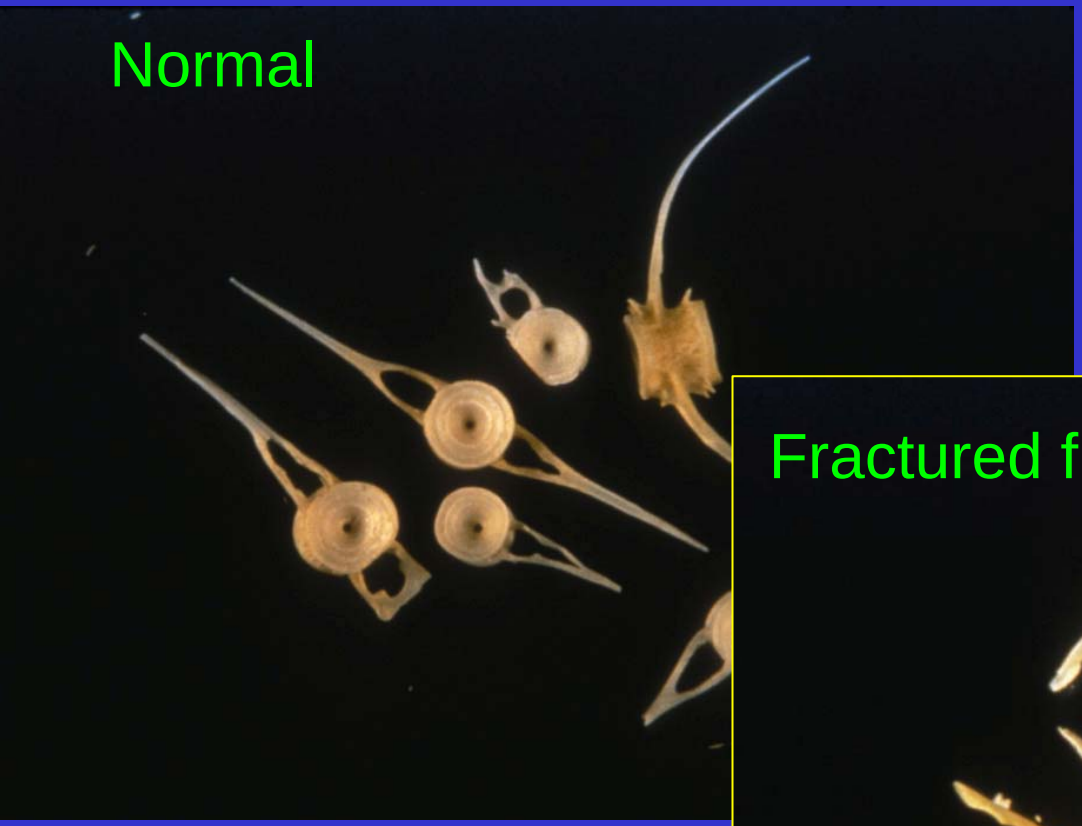
Spinal Injury Classification

Lateral view

Spinal Injury Classification

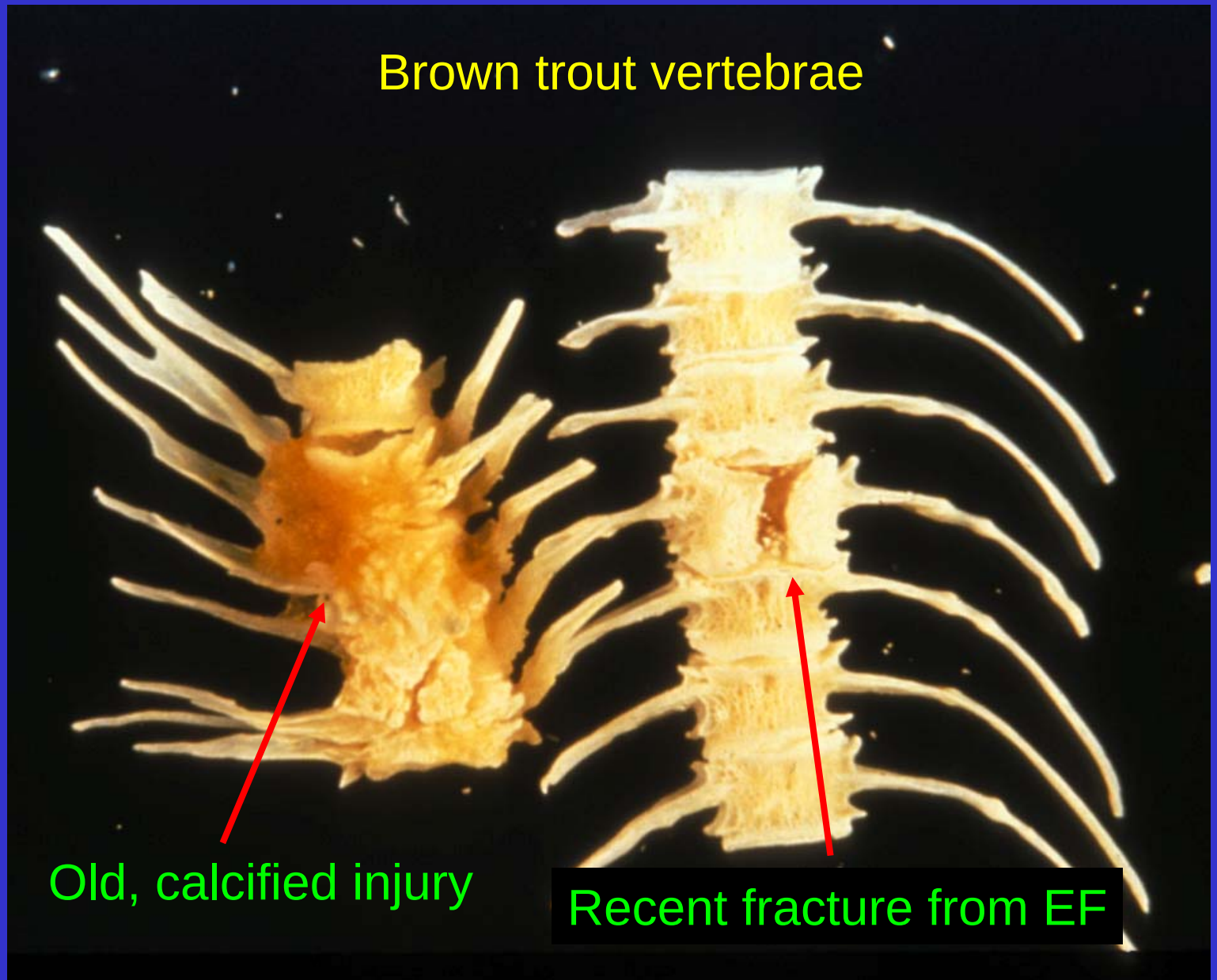
Dorsal view

Spinal Injury



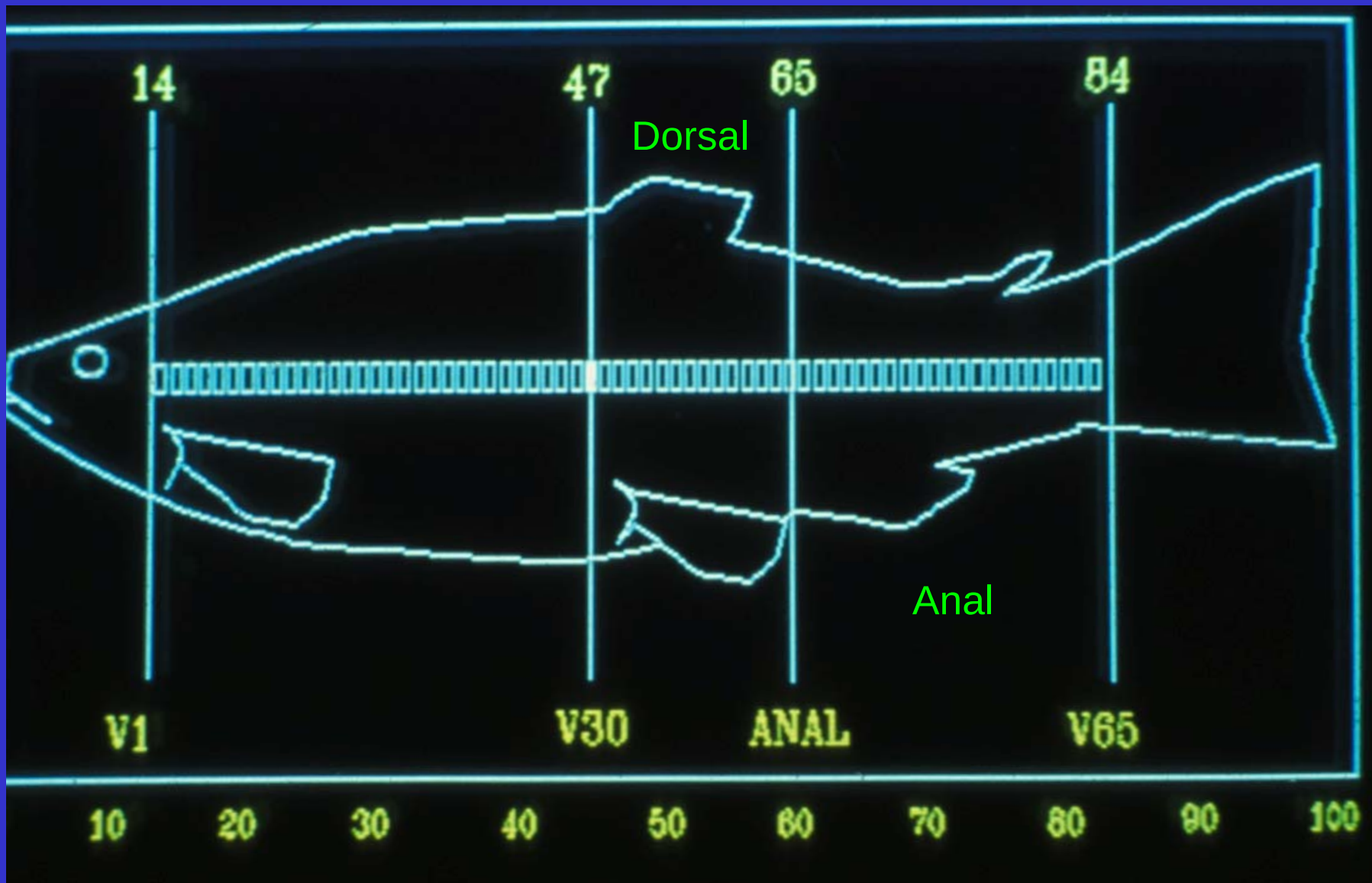
Brown trout vertebrae

Spinal Injury

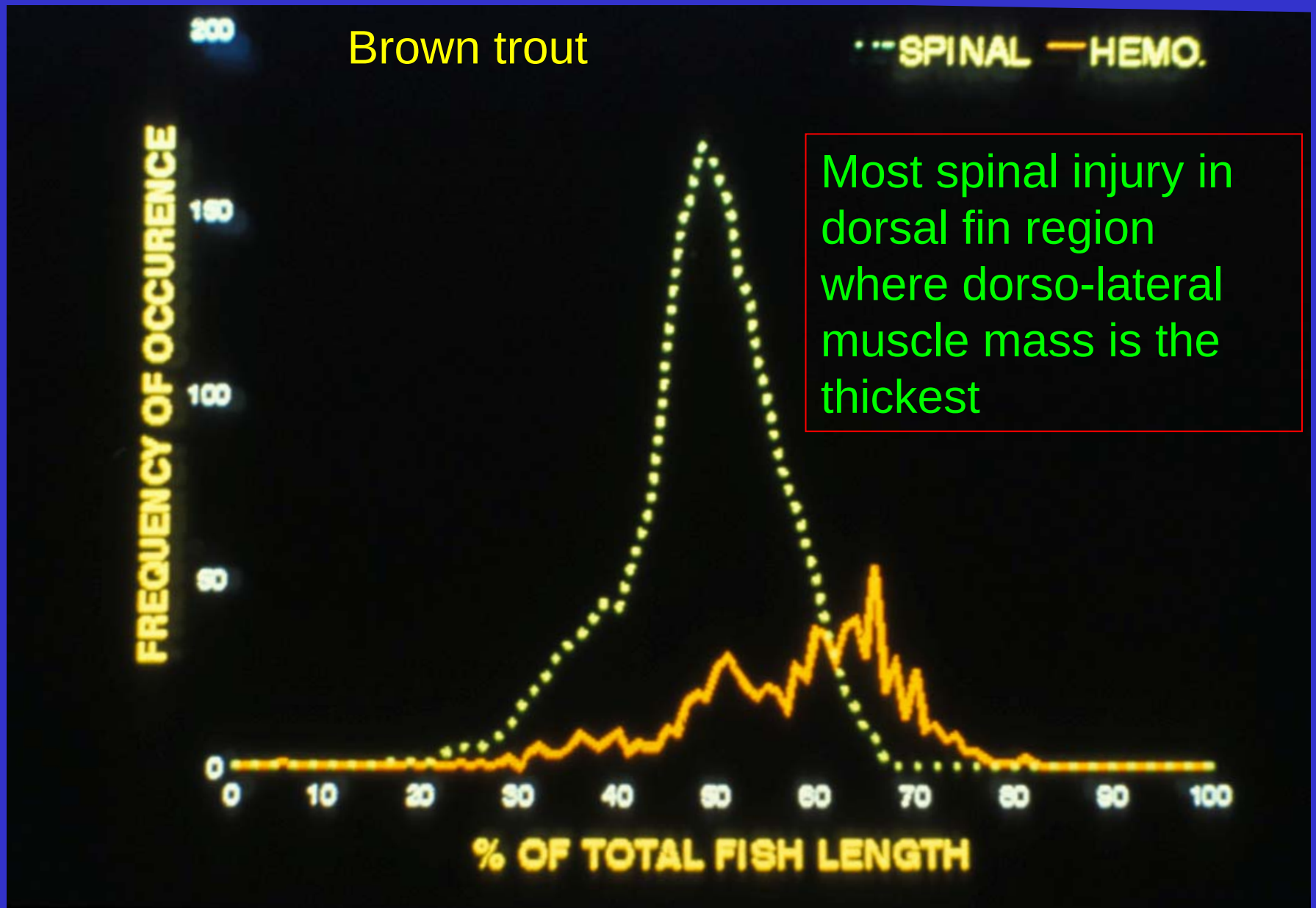


Location of Internal Injuries

% of Length Posterior from Snout



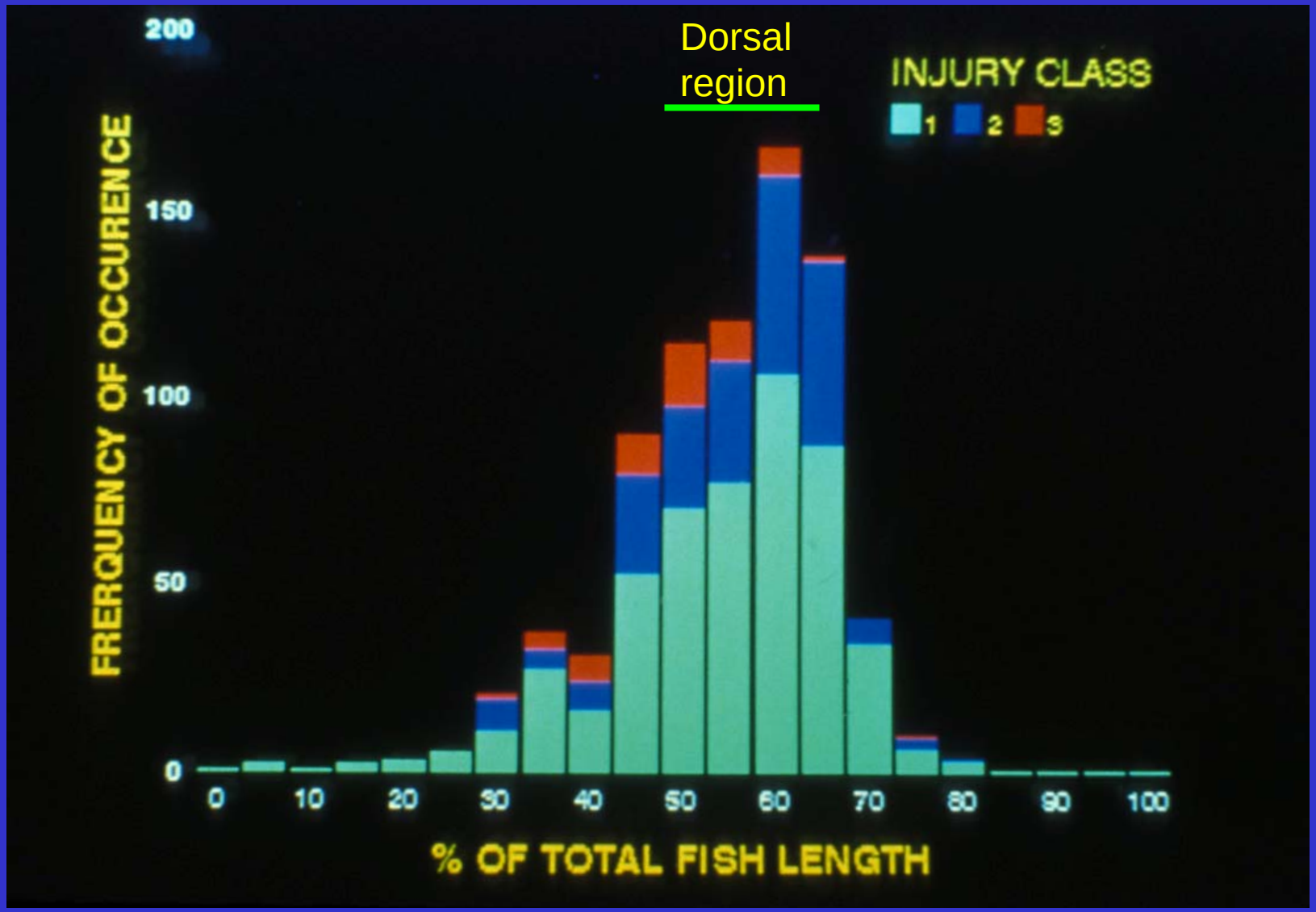
Location of Internal Injuries



Most spinal injury in dorsal fin region where dorso-lateral muscle mass is the thickest

Location of Internal Injuries

Brown Trout



Injury-related Effects of EF

- Injured fish, even if severely injured, can have low mortality
- Injured fish often have reduced growth rates
- Injured fish may have reduced reproductive potential
- Population effects (e.g., % of population injured) often negligible

Electrical Factors Increasing Injury Rates

- Waveforms leading to injury rule-of-thumb is AC > PDC > DC (not always true)
  - AC use in low conductivity waters has been observed to result in low injury to trout
  - 60 Hz PDC less injurious than DC to Cape Fear Shiners
- Higher PDC frequency (at least to 120 Hz) = higher injury rates
- Higher voltage = higher injury rates
- Pulse width not as important (for injury but maybe for stress)
- What about duration of shocking exposure?

% Bluegills (Centrarchidae) with Spinal Injury

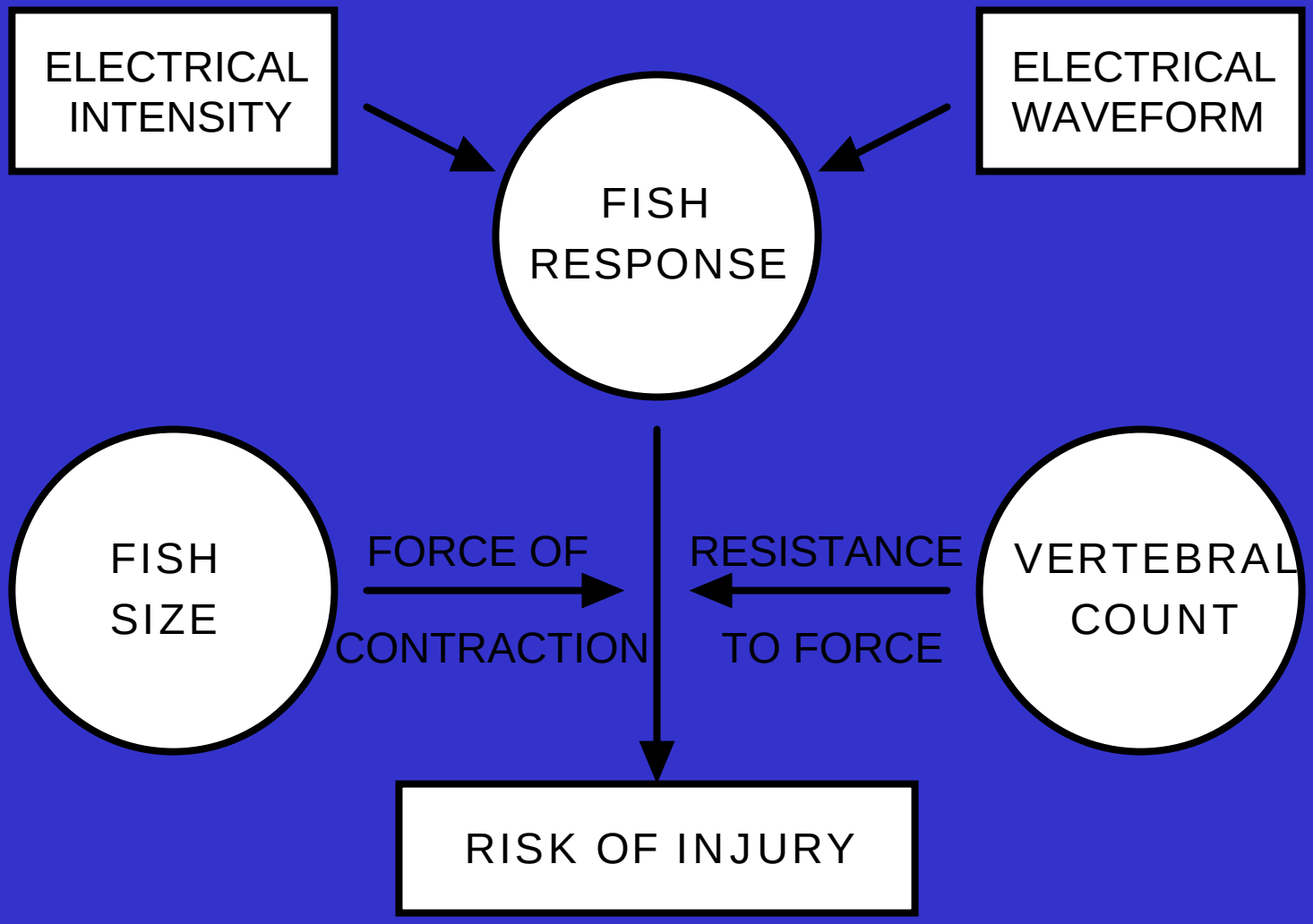
Exposure time (sec)	AC 230 V, 1.3 amp 299 Watts	AC 115 V, 2.0 amp 230 Watts	DC 115 V, 1.9 amp 219 Watts
1	14.7	2.7	1.3
5	10.7	5.3	0
10	12.0	2.7	1.3
30	13.3	5.3	2.7
60	10.7	4	1.3
90	16.0	5.3	2.7
120	9.3	6.7	1.3
Mean	12.2	4.6	1.5

Duration of shock does not increase injury rate

Biological Factors Increasing Injury Rates

- Greater fish length = higher injury rates
- Higher vertebral # (esp. > 40) = higher injury rates
- Immobilization response, particularly tetany = higher injury rates

Fish Injury Risk Model



Actions to Lower Probability of Trauma in Fish

(Page 10-6)

- Use electrodes with the largest effective diameter feasible
- Remove fish quickly from the field as far from the electrodes as possible
  - Length of exposure does not appear to effect injury rate
  - Length of exposure does effect stress levels

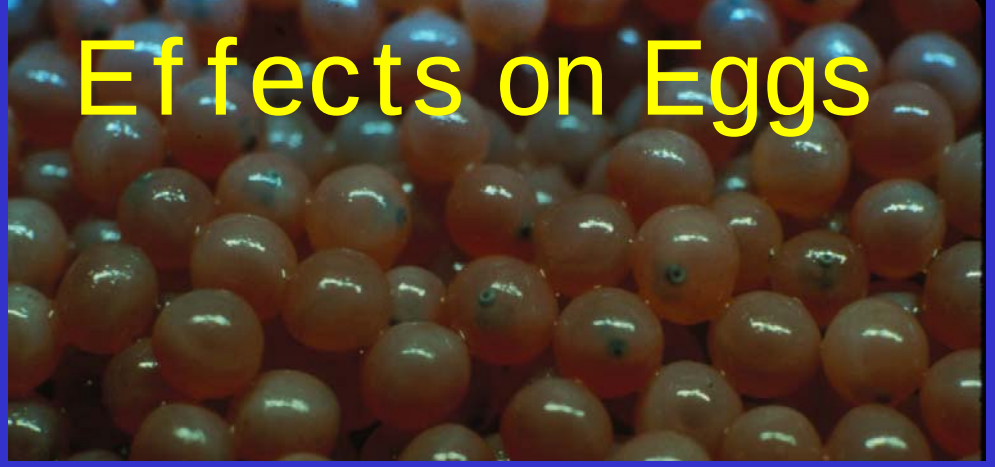
Actions to Lower Probability of Trauma in Fish (continued)

- Use low frequency PDC or continuous DC if possible
- Adjust power levels to the minimum needed for effective capture
- Hold captured fish in optimal conditions
- Consider using a different sampling technique for first capture in M-R studies

Actions to Lower Probability of Trauma in Fish (continued)

- Procedure to determine the threshold level for electrofishing with PDC (page 10-7)

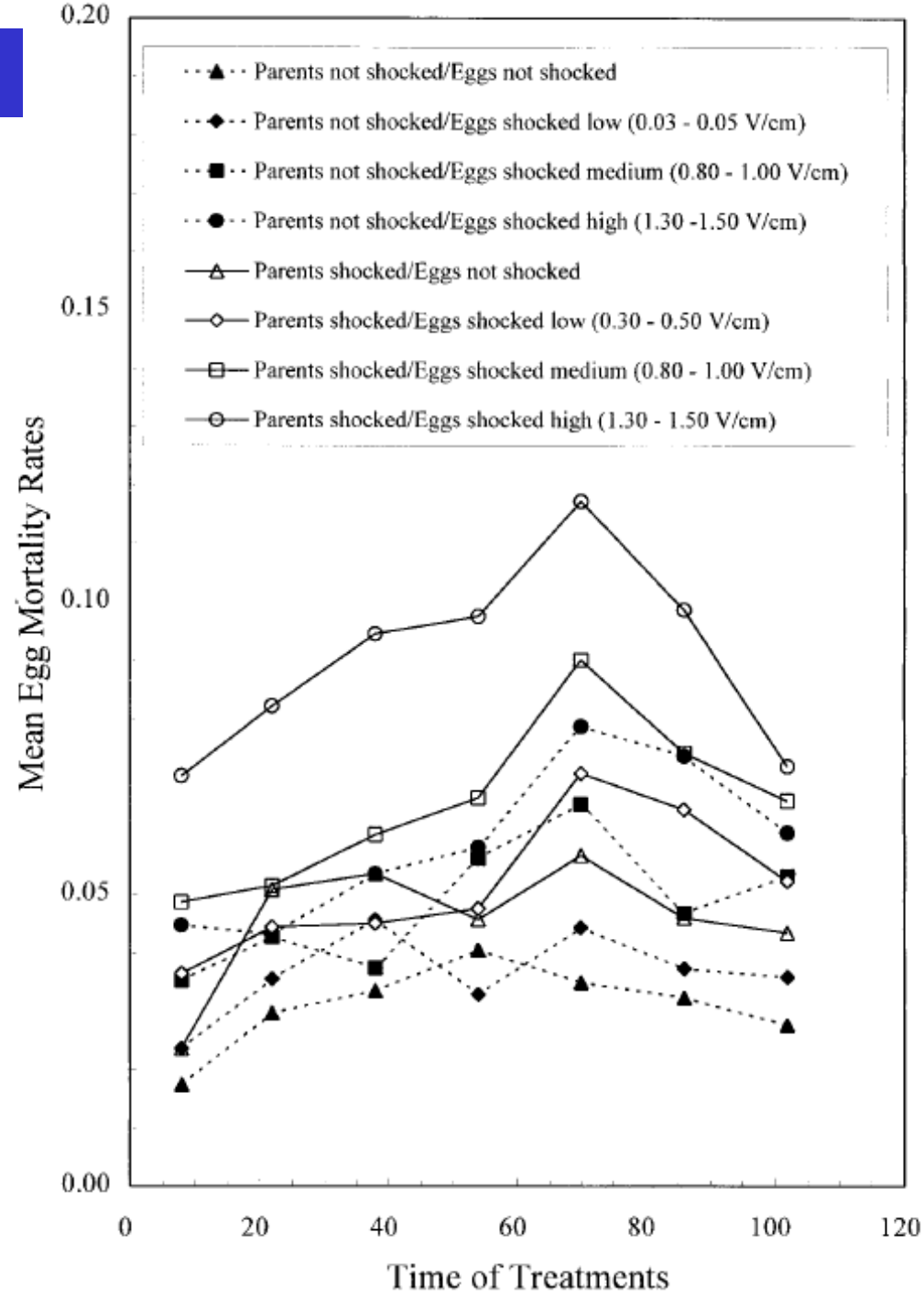
Effects on Eggs



- Egg mortality can occur *in vivo* (before spawning)
- Fertilized egg mortality can occur and susceptibility is similar to that of mechanical shock (middle to late epiboly)
- Mortality level of fish eggs can depend upon electrical intensity, stage of development, and whether parents were shocked
- However, increased level of mortality may be negligible, especially given the field map pattern of backpack shockers

Effects on Eggs

Arctic grayling



Electroshock Effects on Invertebrates

(Page 10-8)

- Little studied, but...
- No effects on Scottish freshwater pearl mussel (*Margaritifera margaritifera*) (Hastie & Boon 2001);
- Some very recent unpublished work at North Carolina State Univ. on freshwater mussel (Unionidae) injury by electrofishing

Electroshock Effects on Invertebrates

(Page 10-8)

- Increased stream drift of macroinvertebrates (reaction that may lead to more efficient sampling for biomonitoring; see Taylor et al. 2001, Can. J. Fish. Aquat. Sci. 58:437-445)

- No effects on survival, growth rate, development, or longer-term drift behavior of a mayfly (*Baetis bicaudatus*) (Taylor et al. 2001, Can. J. Fish. Aquat. Sci. 58:437-445)

- Mortalities in field noted for *Hexagenia* mayflies in Michigan