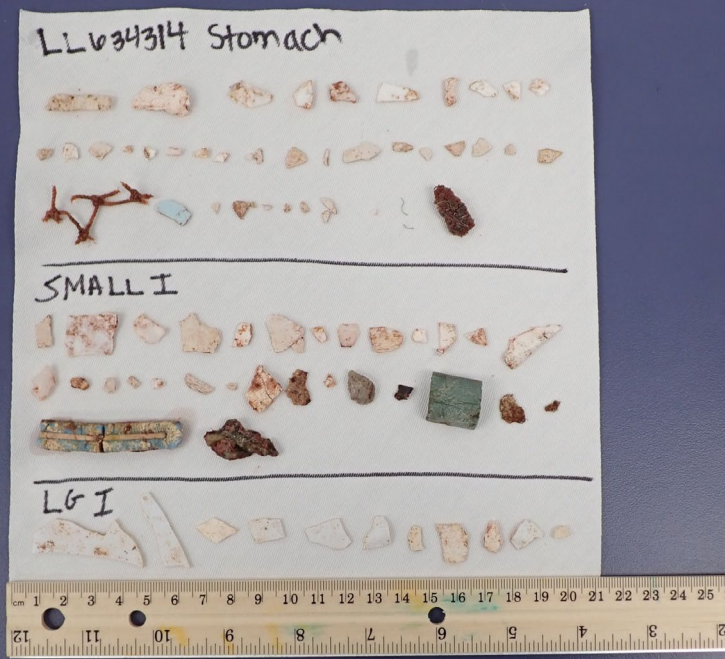


Quantifying harm to sea turtles from ingested plastic:

Review of literature and guidelines for reporting evidence of harm



Katherine Shaw
Darrielle M. Williams
Thierry Work
George H. Balazs
Irene K. Kelly

Mark Flint
Jaxson T. Shaw
Melissa R. Jung
Shandell Brunson
Jennifer M. Lynch

Sea Turtle Interactions with Marine Debris



Entanglement



Habitat
Damage



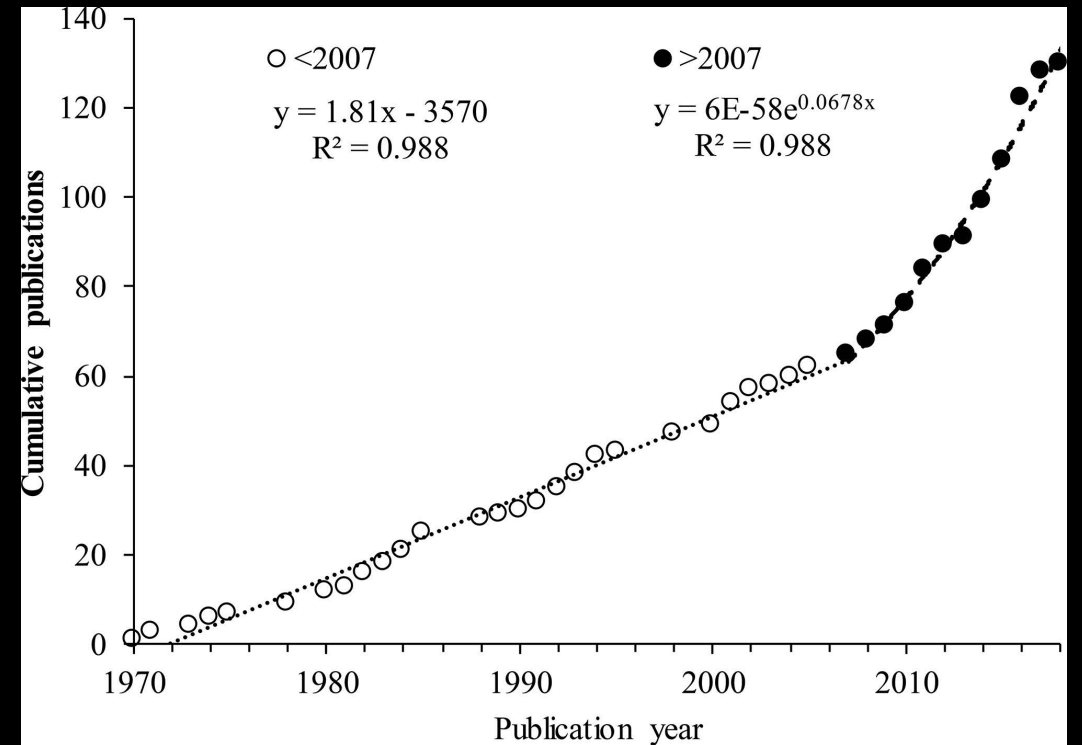
Ingestion

First record of plastic ingestion in sea turtles-

A. Carr pers. comm. in Cornelius 1975



Current publication trend- plastic ingestion in sea turtles



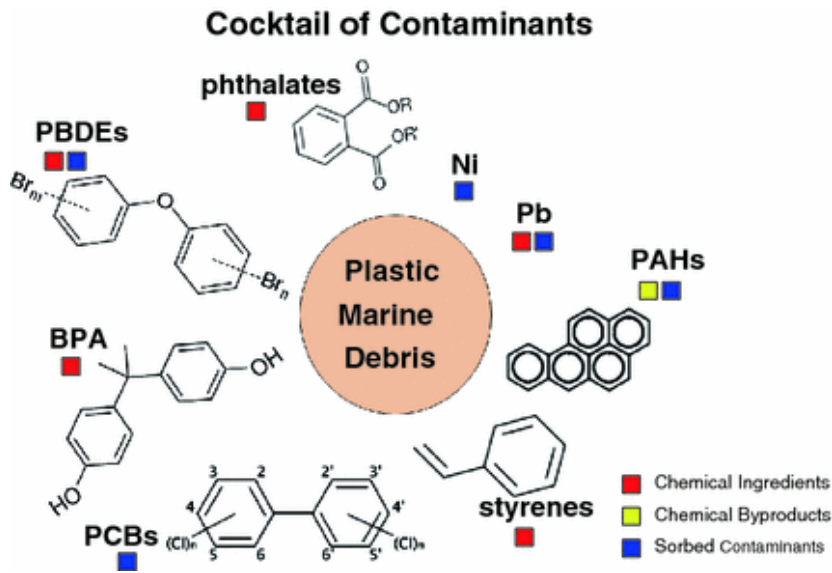
Potential Effects of Plastic Ingestion

Sublethal:

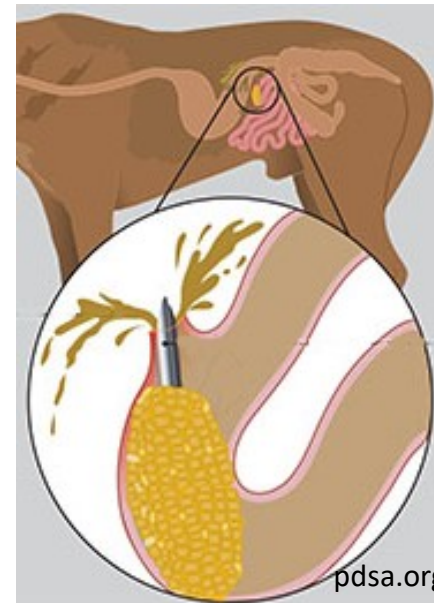
- Dilution of nutrients
- Exposure to harmful chemicals

Lethal:

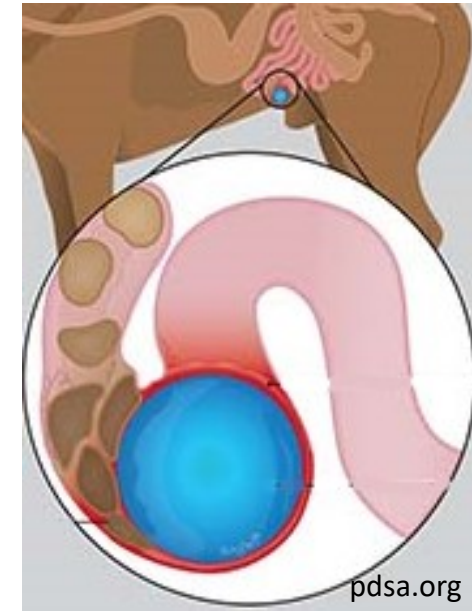
- Obstruction
- Perforation
- Torsion



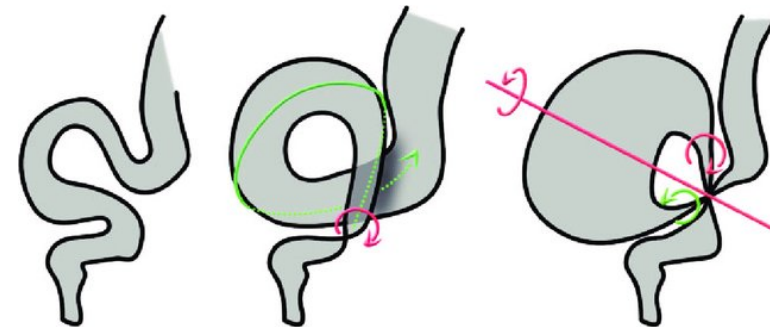
Rochman 2015



pdsa.org



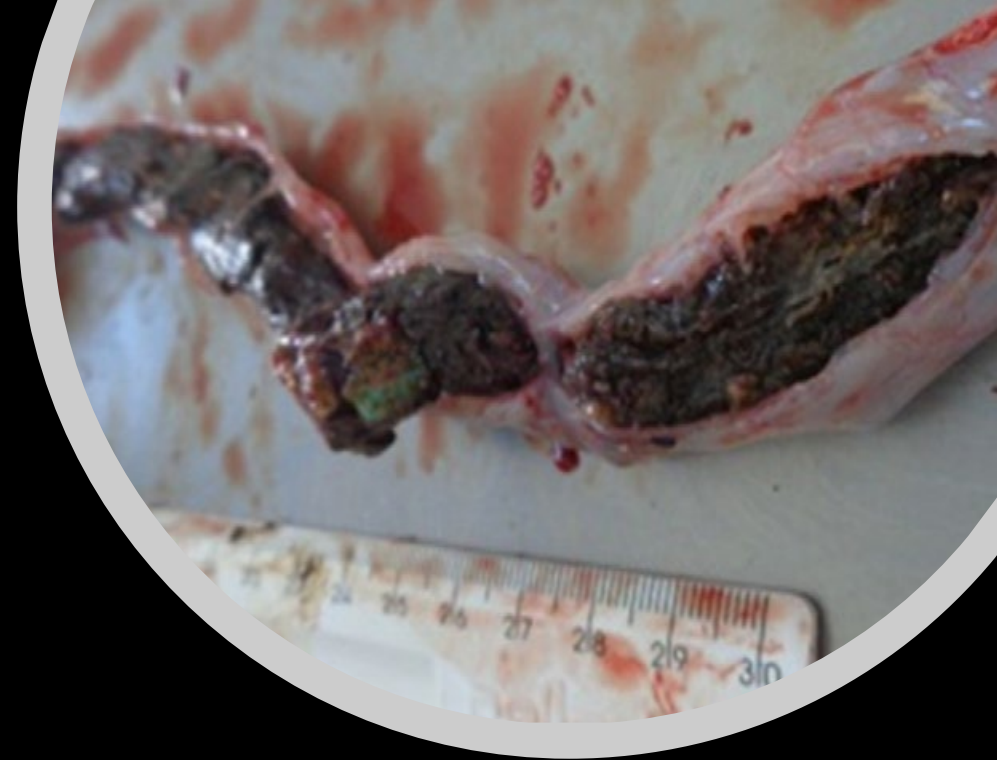
pdsa.org



Christophe Vandendries

Presence of plastic ≠ death by plastic ingestion

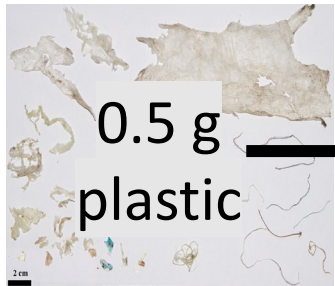
- Bolus of food/digested matter is not always an obstruction
- Emaciated turtle with plastic in its digestive system doesn't always mean it died by plastic ingestion



How much plastic must a turtle ingest to cause harm?

Clukey et al. 2018 and Jung et al. 2018

Santos et al. 2015



0.5 g plastic

Block the GI tract of a juvenile green sea turtle

Wilcox et al. 2018

14 pieces of plastic

50% probability of death

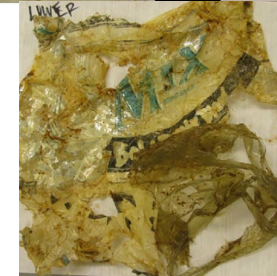
226 pieces of plastic

Certain death

52 ± 67 pieces of plastic

11.7 ± 17.4 g plastic

NOT killed by plastic ingestion (drowned by long-line fishery)



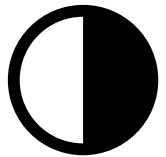
Goals of Review



Compile literature on effects of plastic ingestion



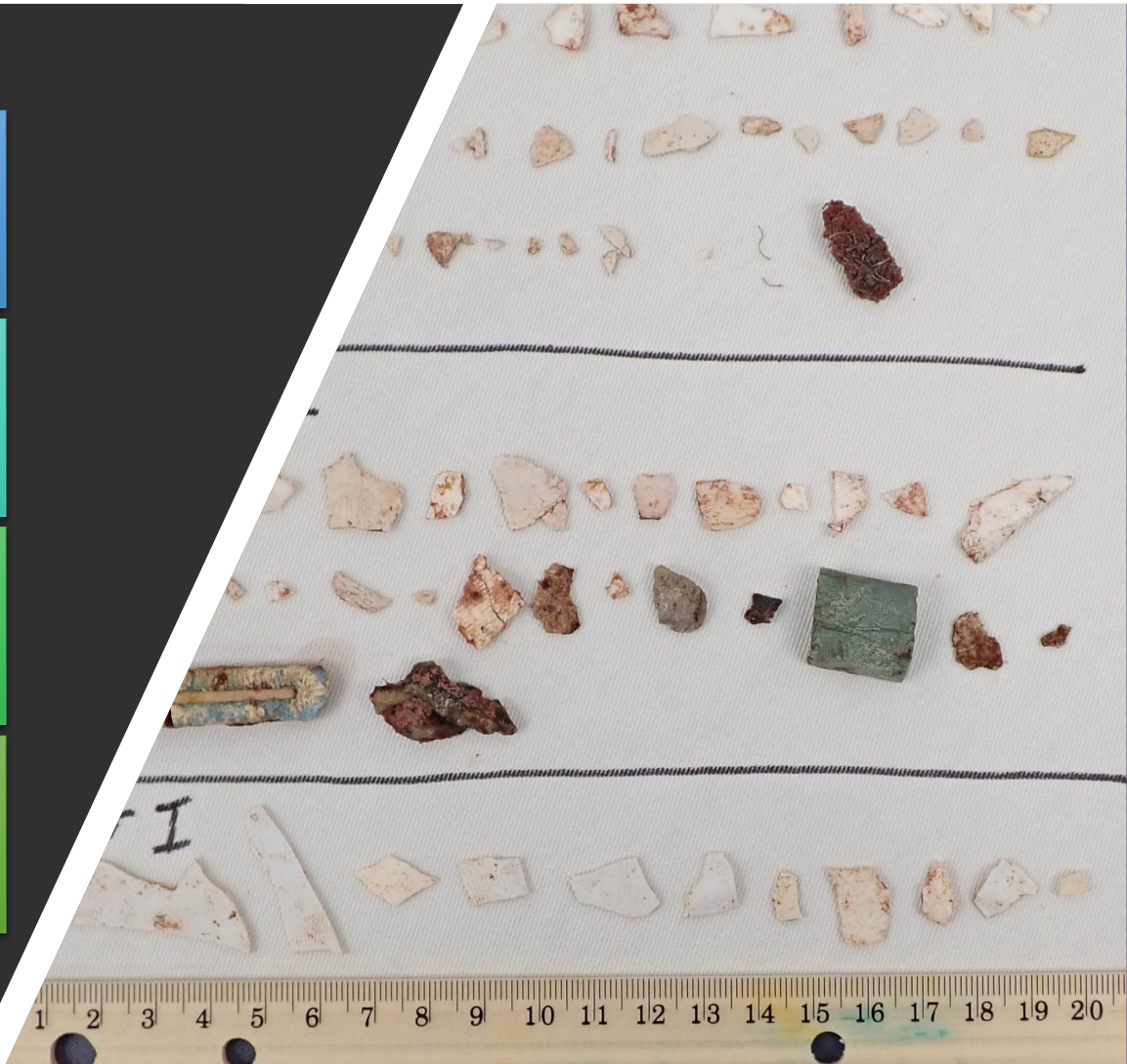
Score literature based on weight of evidence reported



Determine if a LD_{50} for plastic ingestion is possible



Provide reporting recommendations for future studies



Type of Study

- Exposure (2 pts)
- Live/ Known COD (1 pt)
- Dead Stranded (0 pts)

Photo of Injury

- Yes (1 pt)
- No (0 pts)

Veterinarian Consulted?

- Yes (1 pt)
- No (0 pts)

Complete Description? (shape, type, mass, polymer)

- Complete (3 pts)
- Two+ Descriptors (2 pts)
- One Descriptor (1 pt)
- Nothing (0 pts)

Evidence of pathology? (perforation, inflammation, etc)

- Yes (1 pt)
- No (0 pts)

Body Condition Described?

- Yes (1 pt)
- No (0 pts)

Postmortem Condition Described?

- Yes (1 pt)
- No (0 pts)

Evidence of Gross or Microscopic Pathology?

- Yes (1 pt)
- No (0 pts)

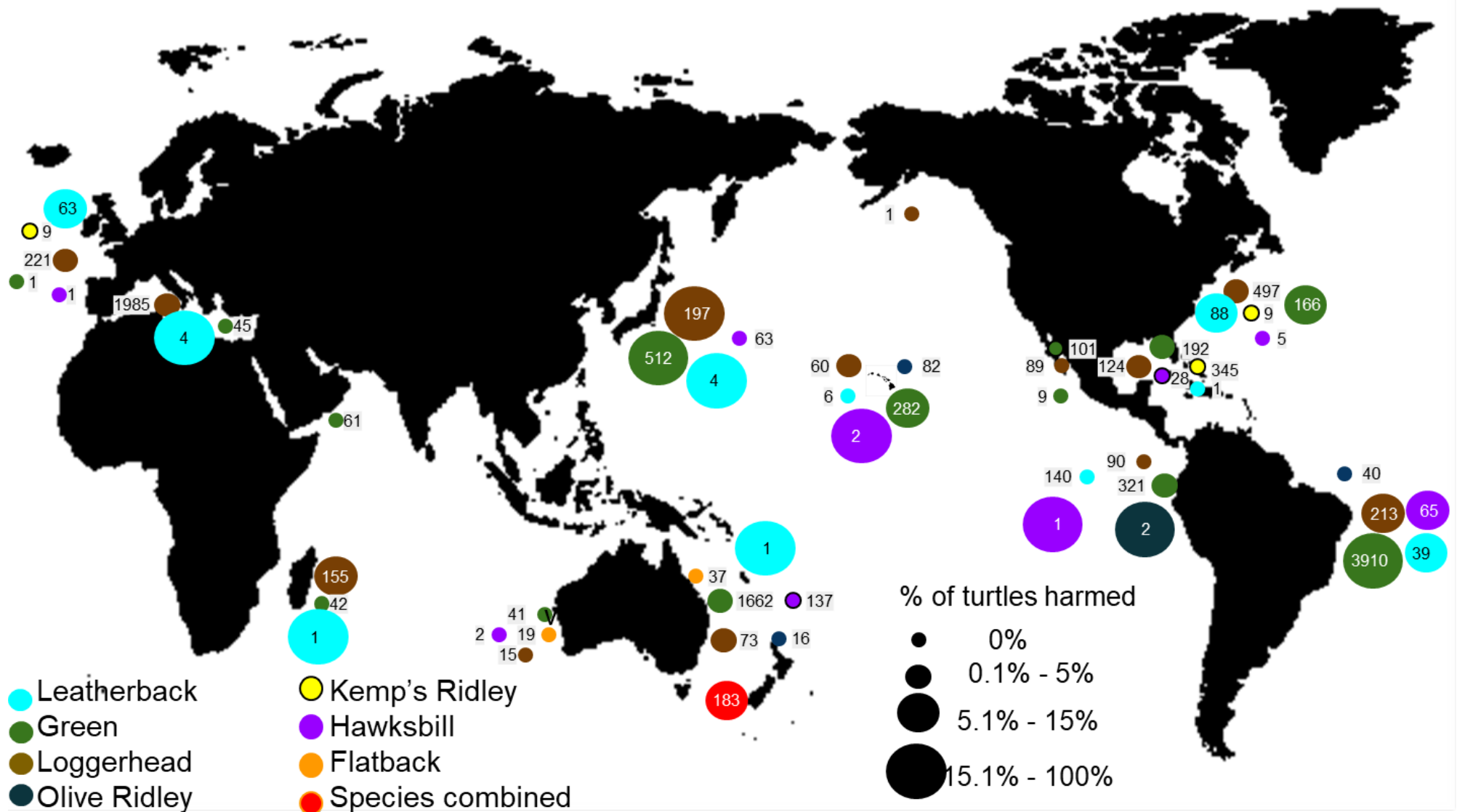
Histo-pathology?

- Yes (1 pt)
- No (0 pts)

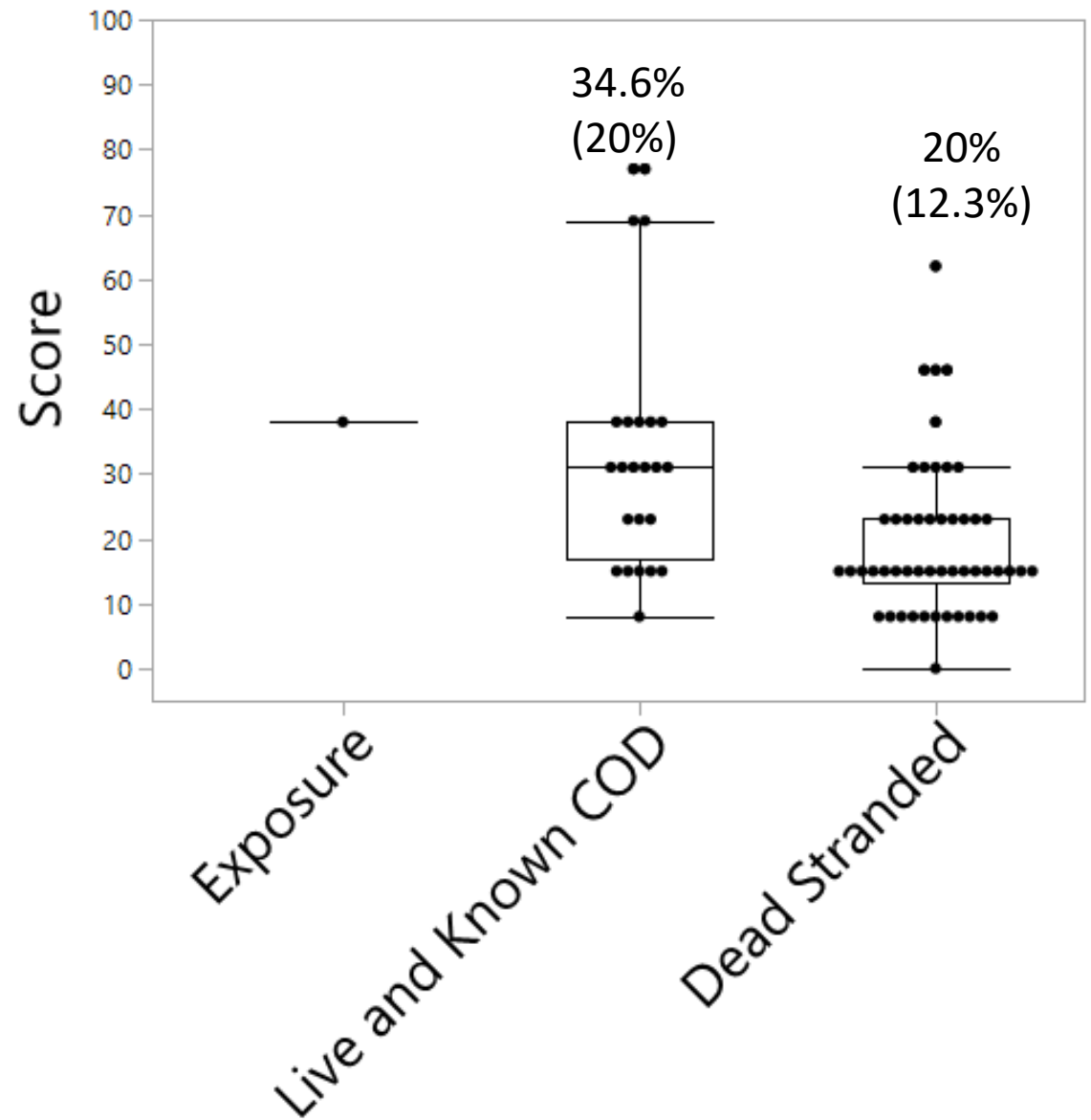
Raw Data Provided?

- Yes (1 pt)
- No (0 pts)

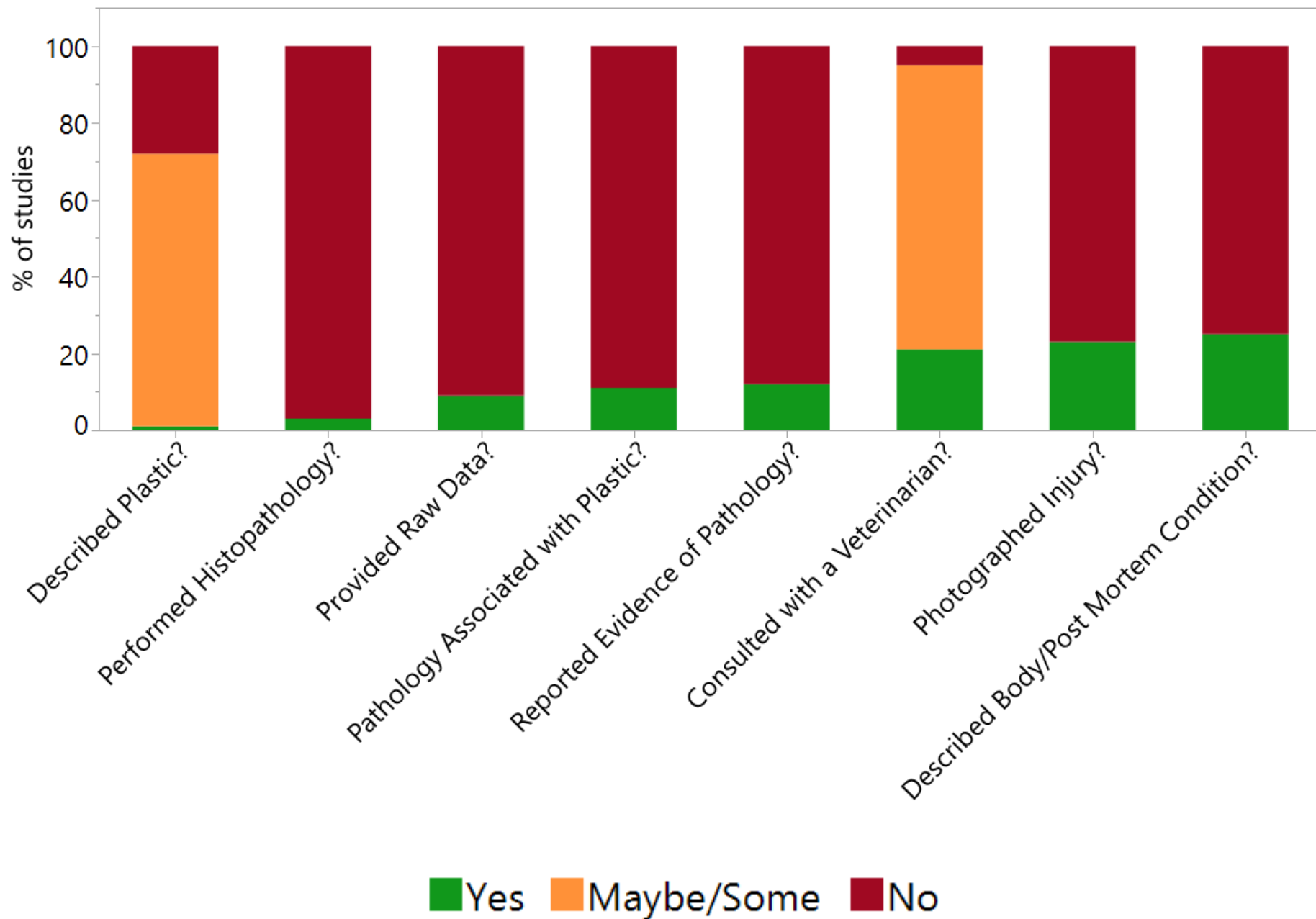
Results: Where was harm seen?



Results:
How did the
studies that
saw harm
score?



Lowest Scoring Categories



Santos

0.5 g plastic → block GI tract

Dead Stranded

Cm

Brazil

Hatchlings to Adults

- Count/Mass
- Type (line, fragment, etc)
- Polymer ID

- Body Condition
- Histopathology
- Photos of injuries

- Individual turtle size
- Individual plastic mass & count
- Plastic Sizes

Wilcox

14 pieces plastic → 50% prob. death
or
226 pieces plastic → certain death

Dead Stranded

Cm, El, Cc, Nd, Lo

Australia

Juvenile

- Polymer ID
- Count/Mass
- Type (line, fragment, etc)

- Body Condition
- Histopathology
- Photos of injuries

- Individual turtle size
- Individual plastic mass & count
- Plastic sizes

Clukey/Jung

52 g plastic or 12 pieces
do NOT cause harm

Dead Bycatch

Cm, Cc, Lo, Dc

Central Pacific

Juvenile

- Polymer ID
- Count/Mass
- Type (line, fragment, etc)

- Body Condition
- Histopathology
- Photos of injuries

- Individual turtle size
- Individual plastic mass & count
- Plastic Sizes

Source of Turtles

Species

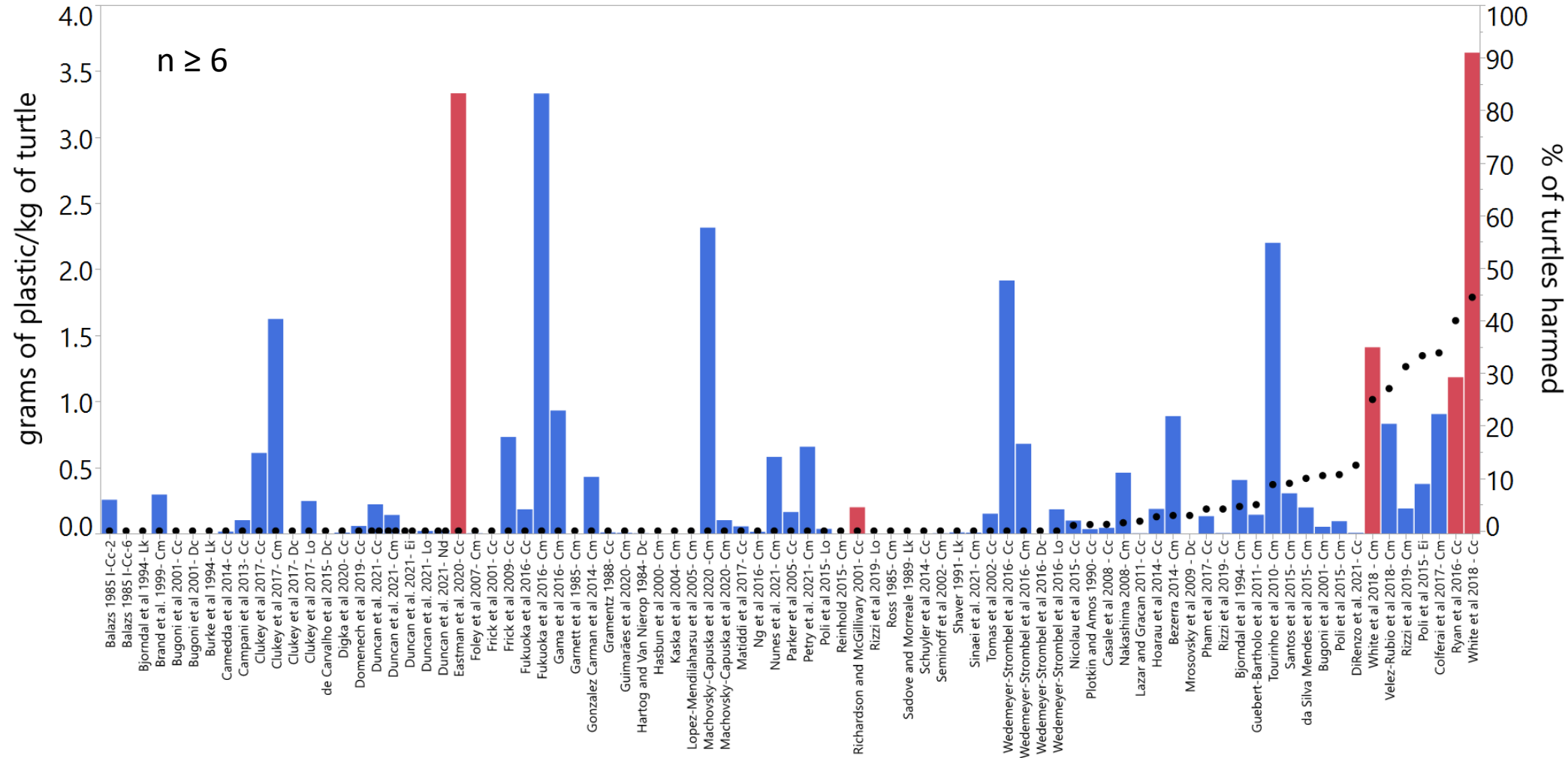
Geography

Age Class

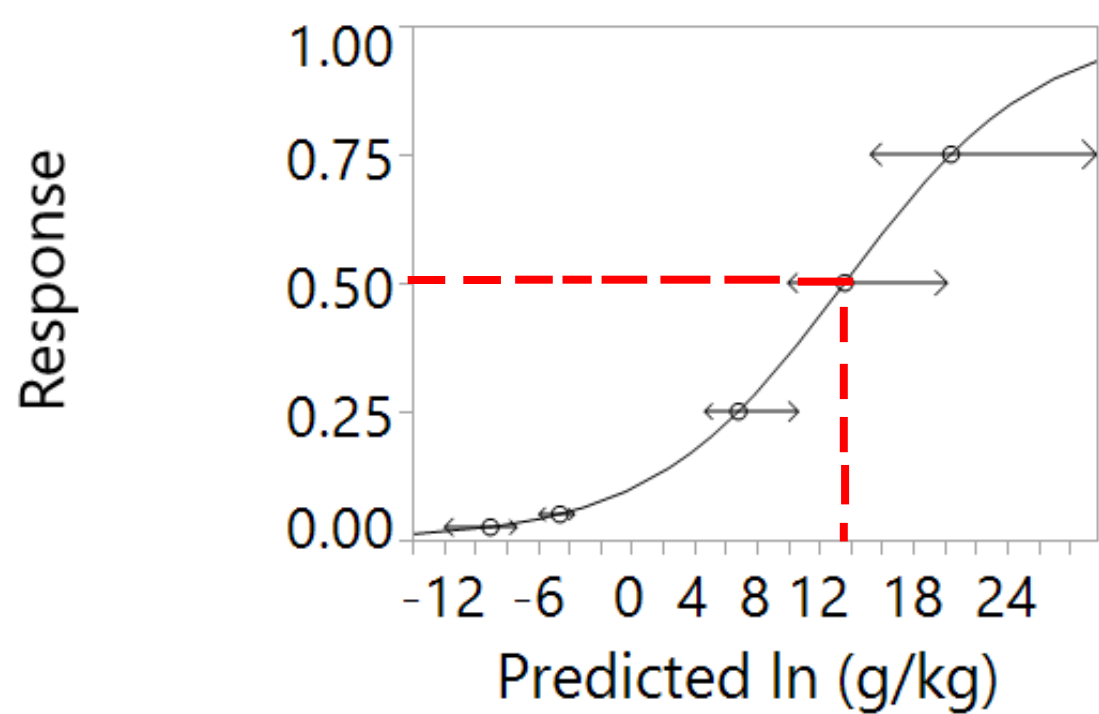
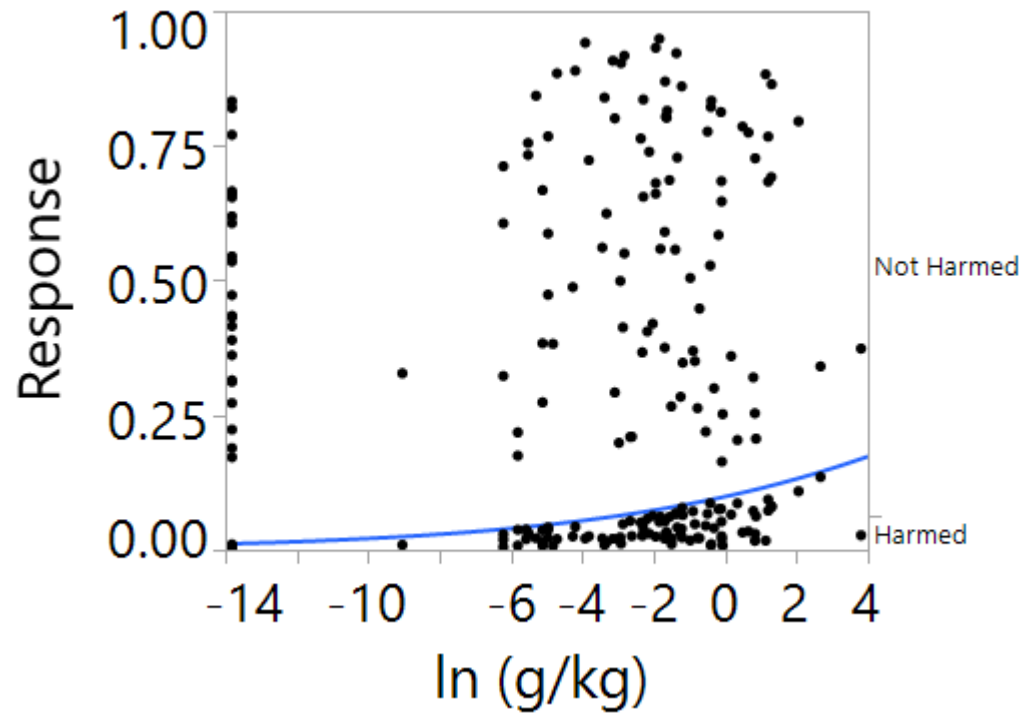
Plastic Description

Info to Determine Cause of Death

Raw Data



Is determining an LD₅₀ possible?



LD₅₀ = 196 g/kg

Stronger Evidence
of Harm from Plastic
Ingestion

Weaker Evidence of
Harm from Plastic
Ingestion



External Body Assessment

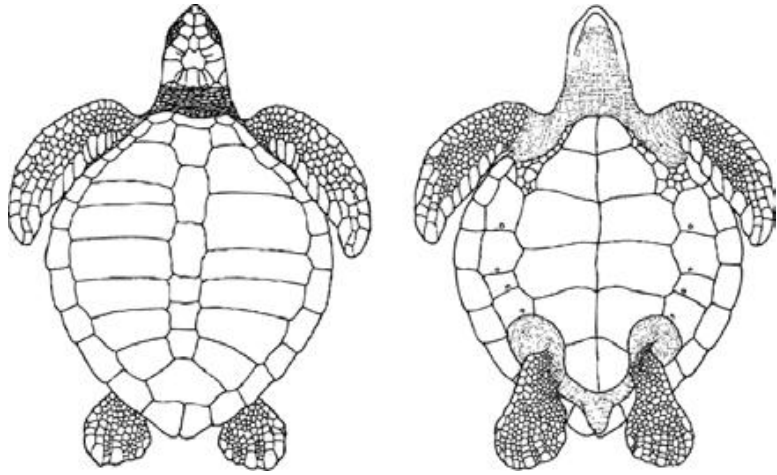
Decomposition:	Fresh	Code 4
External Injuries:	None	Definite injury
Body Condition:	Normal	Emaciated

Body Cavity Assessment

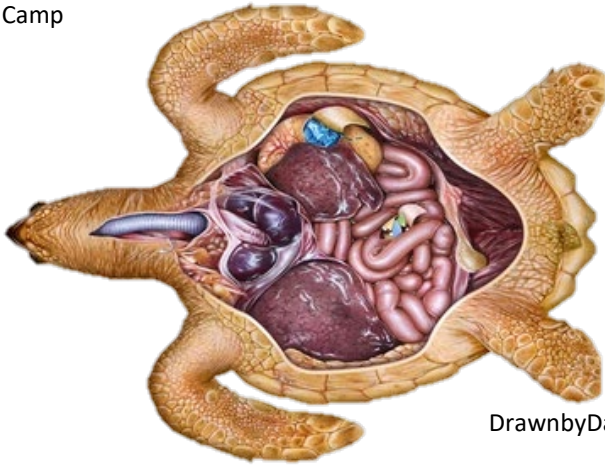
Torsion:	With necrosis or pathology	Without necrosis
Discoloration:	With necrosis or pathology	Without necrosis
Perforation:	With necrosis or pathology	Without necrosis

Internal GI Tract Assessment

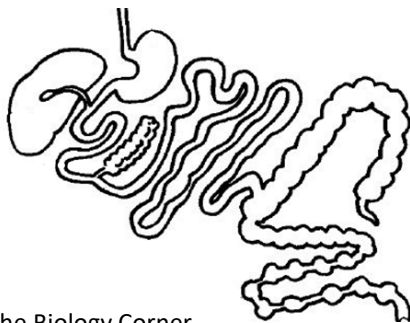
Fishing Hook?:	No, plastic alone	Hook or Bait
Plastic in GI Tract:	Plastic present	No plastic
GI Tissue Diseased?:	Minor disease	Severe Disease
Disease Location:	Near plastic	Far from plastic
Obstruction:	Full obstruction	Partial/no obstruction



Sea Turtle Camp



DrawnbyDawn



The Biology Corner

Marine Turtle Necropsy

Guide for Data Sheet:

- Use each piece of information as a point of evidence for assigning plastic ingestion as the cause of death
- Red end of arrows= strong evidence for plastic leading to cause of death
- Green end of arrows= weak evidence for plastic causing harm

External Body Assessment:

- Species: green (*Chelonia mydas*) kemp's ridley (*Lepidochelys kempii*) olive ridley (*Lepidochelys olivacea*)
 leatherback (*Dermochelys coriacea*) loggerhead (*Caretta caretta*) hawksbill (*Eretmochelys imbricata*)
 flatback (*Natator depressus*)

Measurements at necropsy: Straight or Curved carapace length notch to tip or notch to notch
 _____ cm Weight _____ kg

Photos: side of turtle carapace plastron any external injuries

Decomposition: _____

External Injuries: _____

Body Condition: _____

Body Cavity Assessment:

- Photos: Body cavity after plastron is removed → Assess fat stores: Adequate Little
 Body cavity after connective and fat tissues have been removed
 External surface of GI tract to document any trauma

Signs of Disease on external surface of GI tract:

SEVERE

- Torsion with necrosis or other significant pathology
- Discoloration from necrosis or other significant pathology
- Perforation with necrosis or other significant pathology

MINOR

- Torsion without signs of pathology (peri or post mortem?)
- Discoloration without signs of pathology (post-mortem?)
- Perforation without signs of pathology (Gut contents present in body cavity from cutting open the turtle)
- Inflammation
- Nodules

Internal GI Tract Assessment:

- Is there a fishing hook or bait present in the mouth, esophagus, or stomach? _____
- Open from mouth to cloaca. Record presence and location of plastic _____
- Before moving plastic assess the GI tissue for signs of disease _____
- If no signs of disease, set aside plastic in order of discovery (esophagus, small intestine, etc.) and record GI location in table below

Marine Turtle Necropsy

- If there are signs of disease, note location of disease, and proximity of disease to plastic, take photos

Photos: plastic with diseased tissue diseased tissue alone

- Set aside plastic that caused diseased tissue (culprit pieces) for later analysis

- Take GI tissue for pathology

Severe	Minor
Ulceration*	Inflammation
Full Obstruction	Partial Obstruction**
Perforation	Laceration
Torsion w pathology	Torsion w/out pathology (recent)

*Consider parasites

**Consider starvation as cause of death (not plastics) for empty gut beyond the plastic when emaciated body condition

Post GI Assessment:

Photos: cleaned plastic pieces culprit pieces

- Assess all plastic pieces, including culprit pieces

Turtle ID	Body Location	Type	Color	Opacity	Length (cm)	Width (cm)	Depth (mm)	Photo	Description

Reporting Information:

- Information for each turtle, provide raw data in supporting information table or a publicly available website:

- Count of plastic pieces: _____
- Mass of plastic: _____ g
- SCL of turtle: _____ cm
- Mass of turtle _____ kg
- # of plastic pieces per kg of turtle: _____ pieces/kg of turtle
- g of plastic/kg of turtle: _____ g/kg

- Information for data set: Provide below by species and other groupings of turtles

- Number of turtles assessed for debris: n = _____
- Mean, median, SD, range of # plastic pieces/turtle: _____ pieces/turtle
- Mean, median, SD, range of mass of plastic: _____ g/turtle
- Mean, median, SD, range of mass of turtles: _____ kg/turtle
- Mean, median, SD, range of SCL of turtles: _____ cm
- Mean, median, SD, range# of plastic pieces per kg of turtle: _____ pieces/kg of turtle
- Mean, median, SD, range of plastic/kg of turtles: _____ g plastic/kg of turtle

Conclusions



ENVIRONMENTALLY RELEVANT
CONCENTRATIONS REPORTED TODAY DO
NOT REACH THE CALCULATED LD50



MORE DETAILED AND
STANDARDIZED REPORTING
GUIDELINES ARE NEEDED