A Meta-Analysis of Bycatch Mitigation Methods for Sea Turtles

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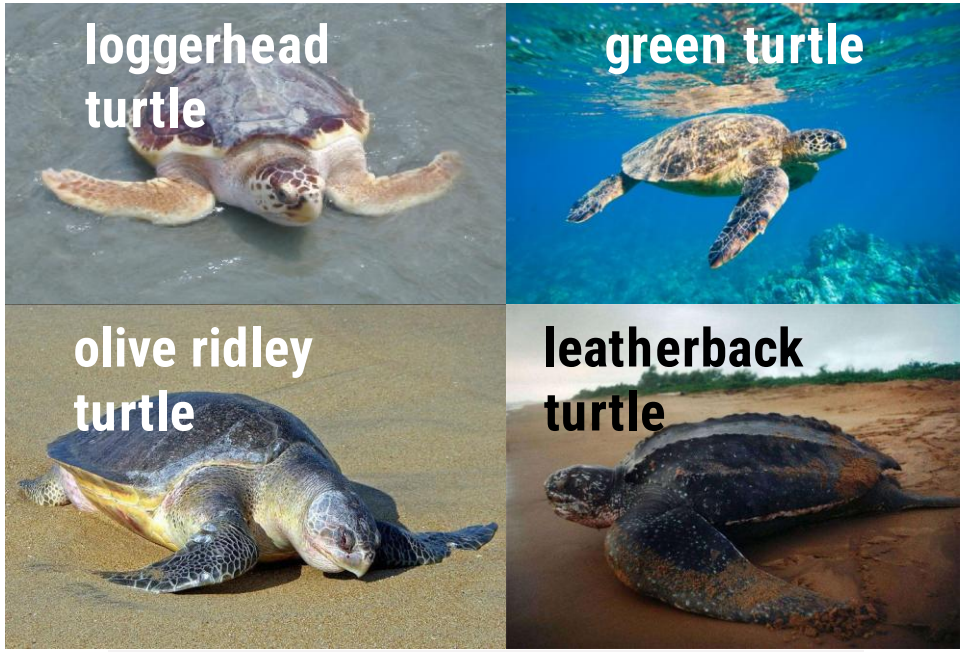
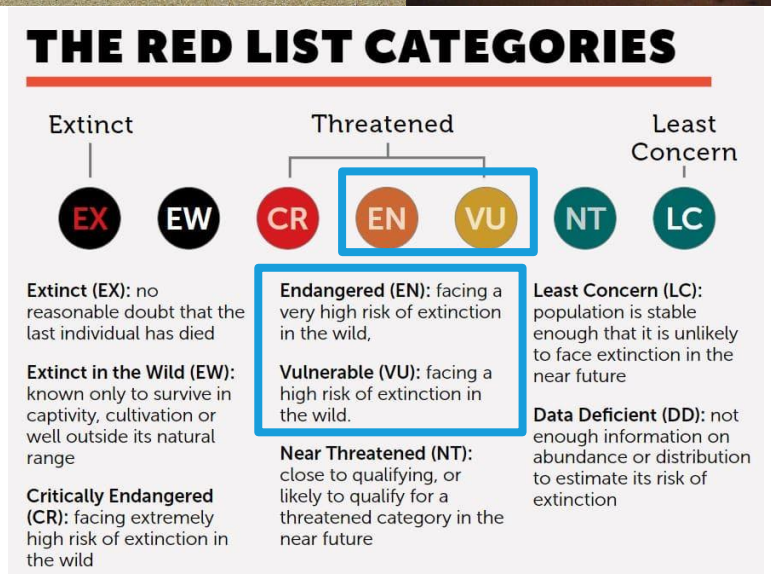
- **Fragmentation:** Mitigation efficacy remains fragmented due to species-specific responses and environmental complexity
- **Single-Factor Focus:** Most studies isolate individual factors (hook or bait)
- **Meta-Analysis:** move beyond case-by-case observations and provide a quantitative foundation for evidence-based policy

- Loggerhead turtle (*Caretta caretta*)
- Green turtle (*Chelonia mydas*)
- Olive ridley turtle (*Lepidochelys olivacea*)
- Leatherback turtle (*Dermochelys coriacea*)





Meta-Analysis Workflow

Data Collection

Identify the source

↓

Search Keywords
"turtle"
"longline"
"bycatch"

↓

Inclusion Crteria

↓

Screening

Effect Size (RR)

$$RR\ (Risk\ Ratio) = (event.e/n.e) / (event.c/n.c)$$

$$confidence\ interval\ lower = exp\ (\ln(RR) - 1.96 \times SE)$$

$$confidence\ interval\ upper = exp\ (\ln(RR) + 1.96 \times SE)$$

$$SE = sqrt\ ((1/event.e - 1/n.e) + (1/event.c - 1/n.c))$$

	The number of captured sea turtles	The number of fishing hooks
Experimental group	event.e	n.e
Control group	event.e	n.c

Statistical Analysis

Heterogeneity Assessment

Statistics: Qtest, I^2, H, τ^2

Model Selection:
High/Med/Low heterogeneity
→ Random/common effects model

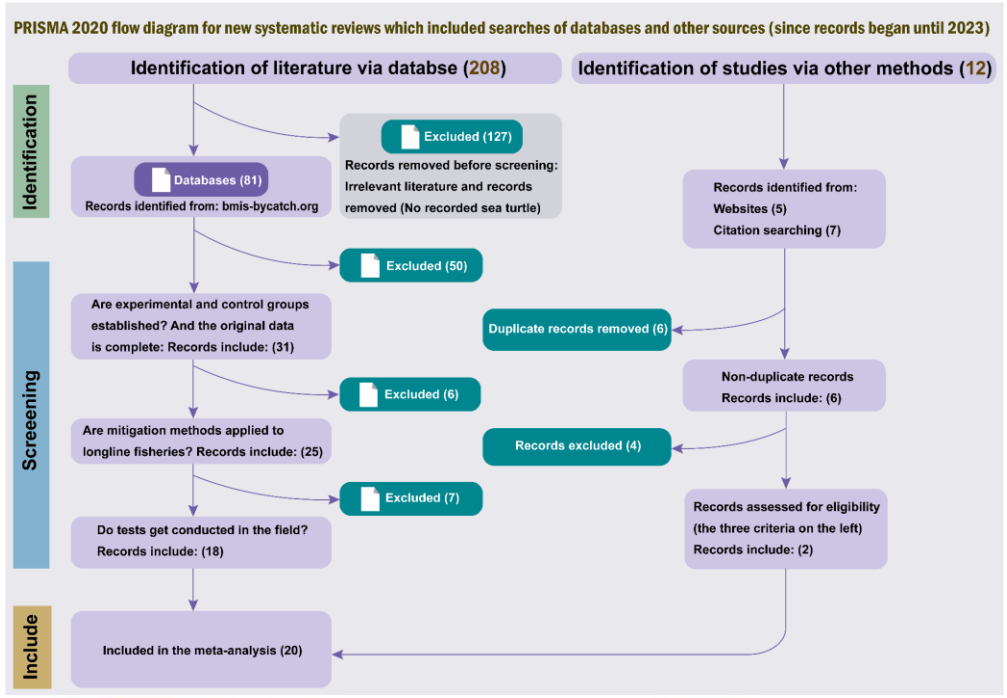
Enhanced Analysis

Robustness (CR2) & Sensitivity

Subgroup Analysis & Meta-Regression

Publication Bias Assessment

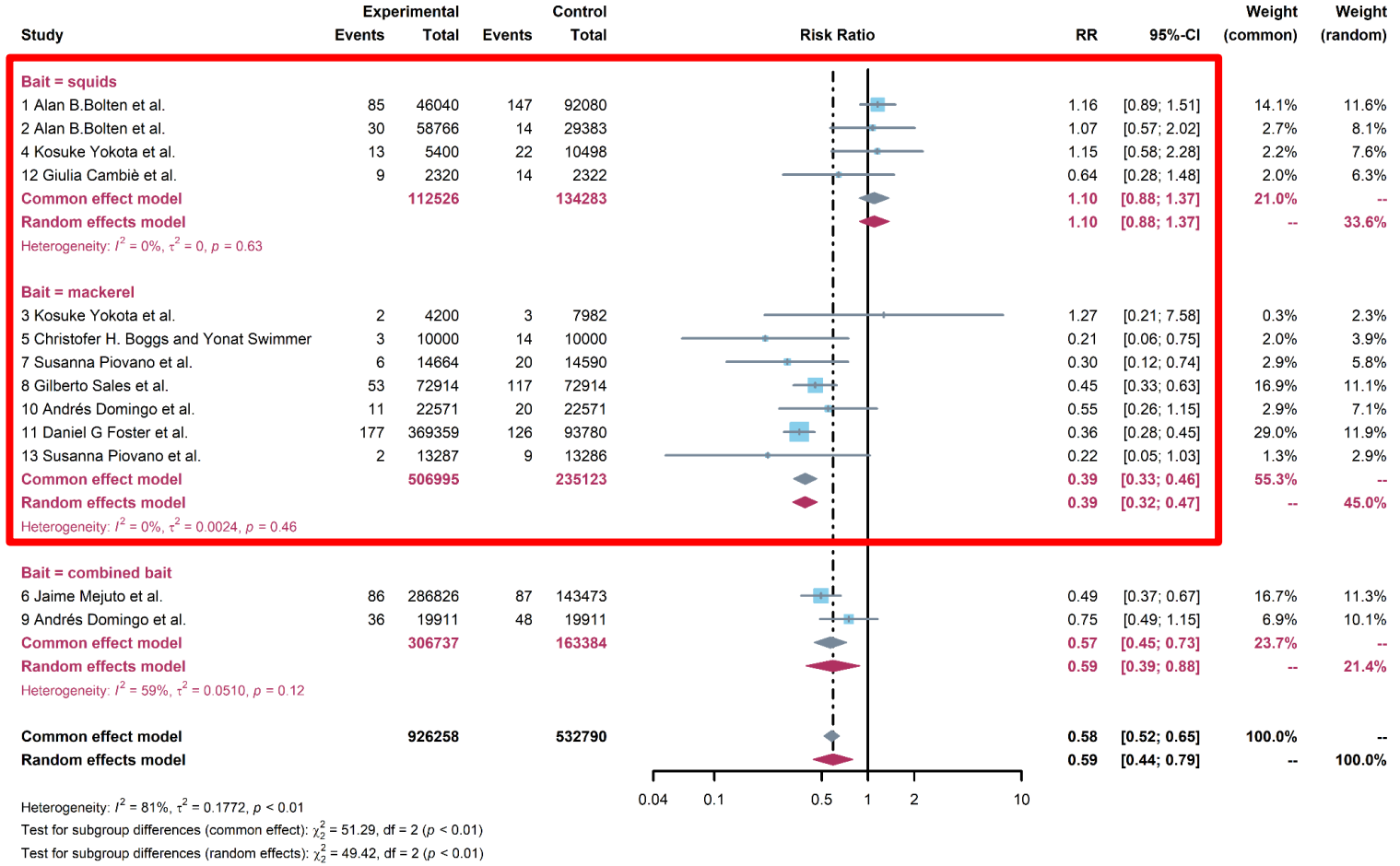
mitigation methods overview



- **Replacing J-style hooks with circle hooks**
- **Using fish bait instead of squid bait**
- *Using circle hooks with a wire appendage*
- *Dyeing the bait blue*
- *replacing fish bait with stingray bait*
- *Using offset hooks, usually between 0° and 10°;*
- *The use of the Hookpod-mini device on branch lines*
- *Using different light types at the end of longline fishing branch lines, including white, blue and green light*

Circle Hooks – Loggerhead

- *Risk Ratio (RR) = 0.59*
- *Significant reduction in bycatch (CI below 1)*
- *High heterogeneity (I^2 ~*
- *Bait type contributes to observed heterogeneity*
- *Hook effect might be influenced by bait type*

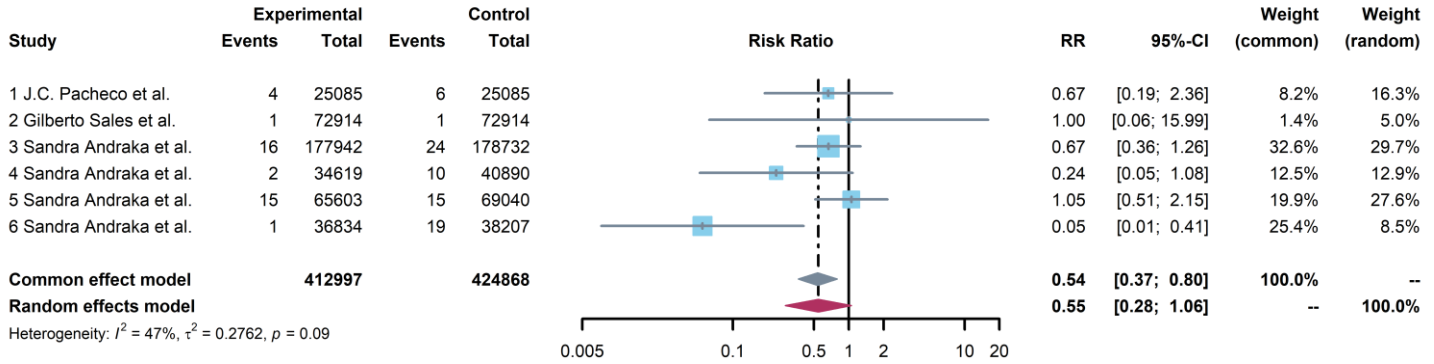


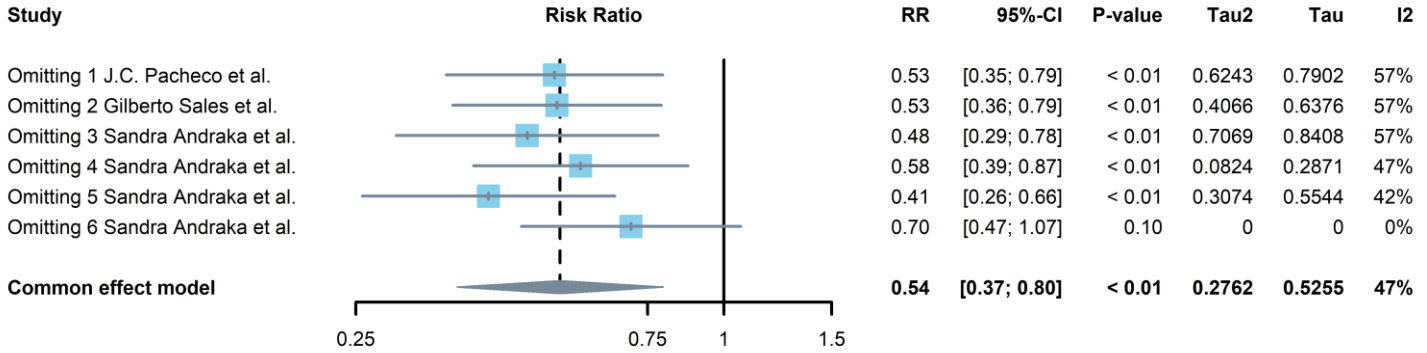
Subgroup analysis of 13 studies on loggerheads

Circle Hooks - Green Turtle

- *RR = 0.55*
- *Confidence interval crosses 1*
- *No significant reduction*
- *Limited number of studies*
  - *I. Few available studies*
  - *II. Small sample size*
  - *III. High uncertainty*

- *Insufficient evidence to support the effectiveness of circle hooks*

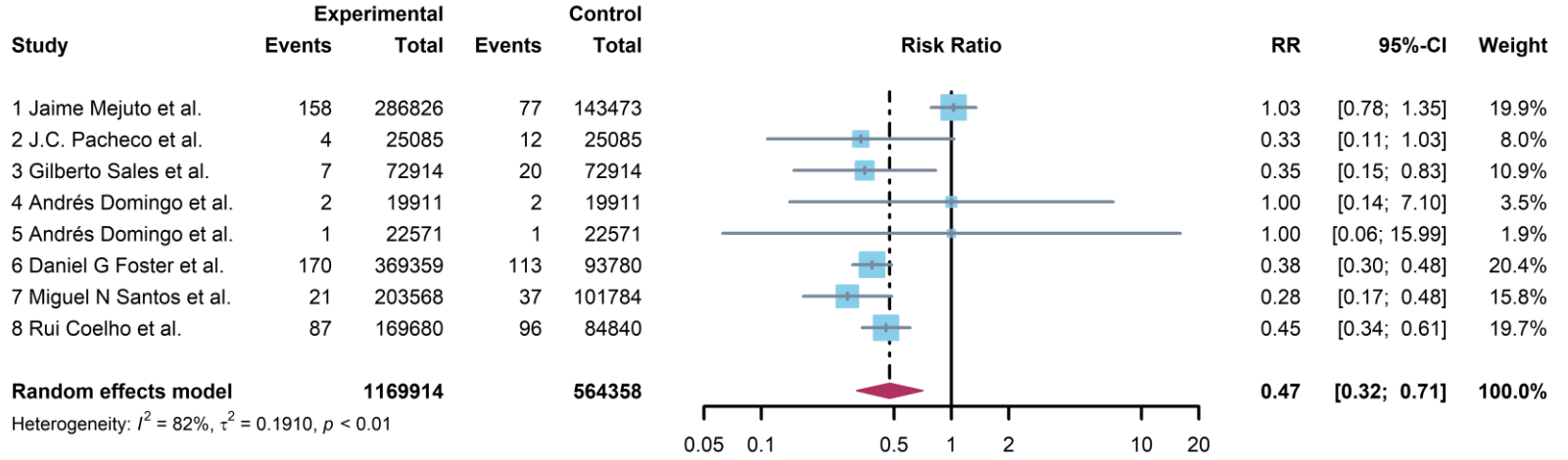


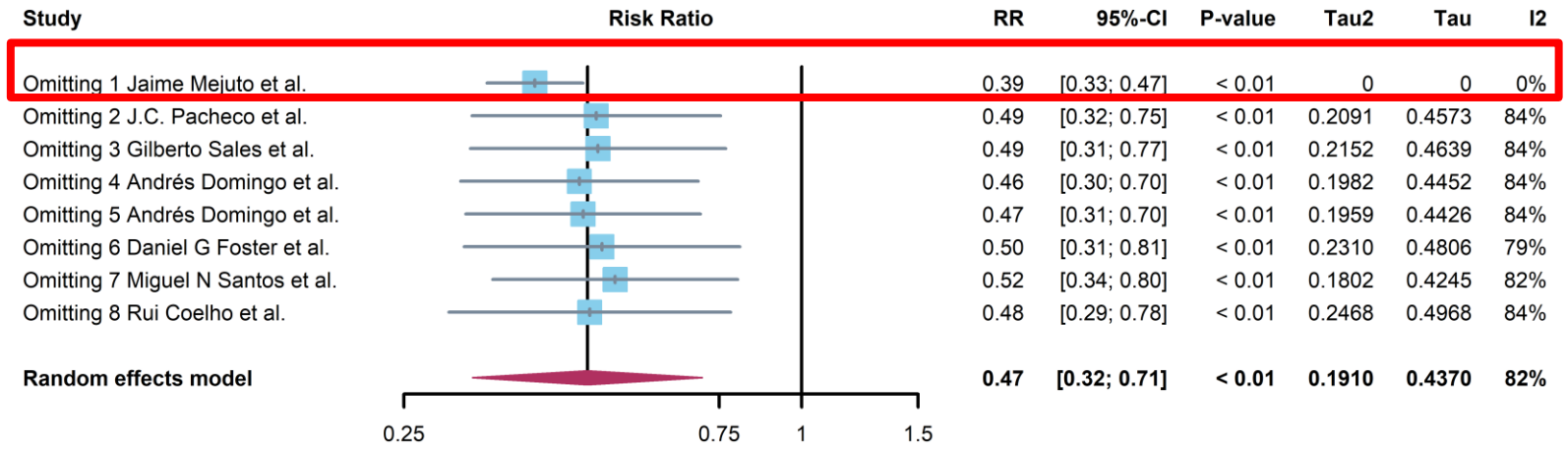


Sensitivity analysis of green turtle

Circle Hooks – Leatherback

- *RR = 0.47*
- *Significant reduction*
- *Clear mitigation effect*
- *Consistent across studies*
- *Study 1 is the source of heterogeneity*

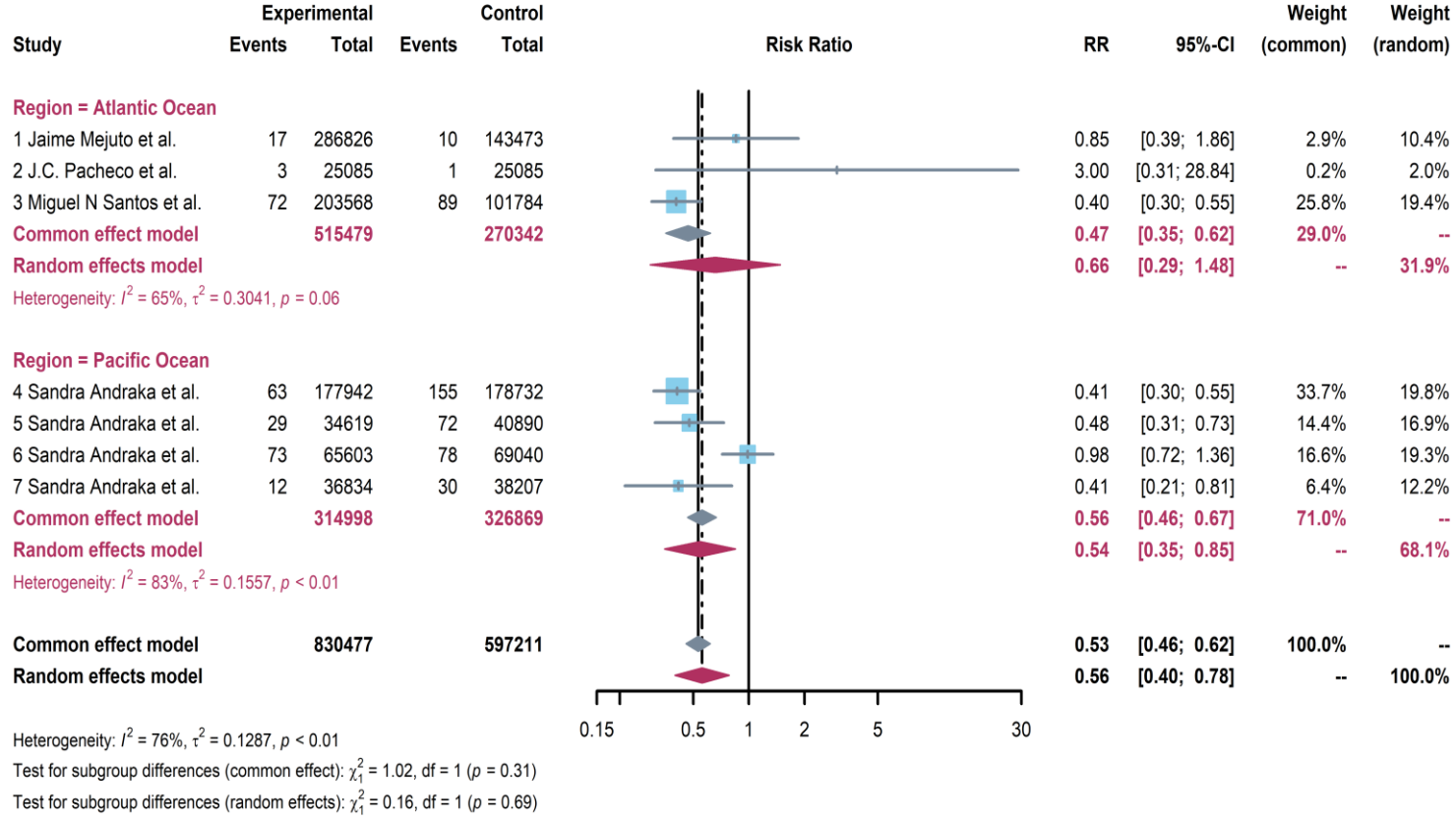




Sensitivity analysis of leatherbacks

Circle Hooks - Olive Ridley

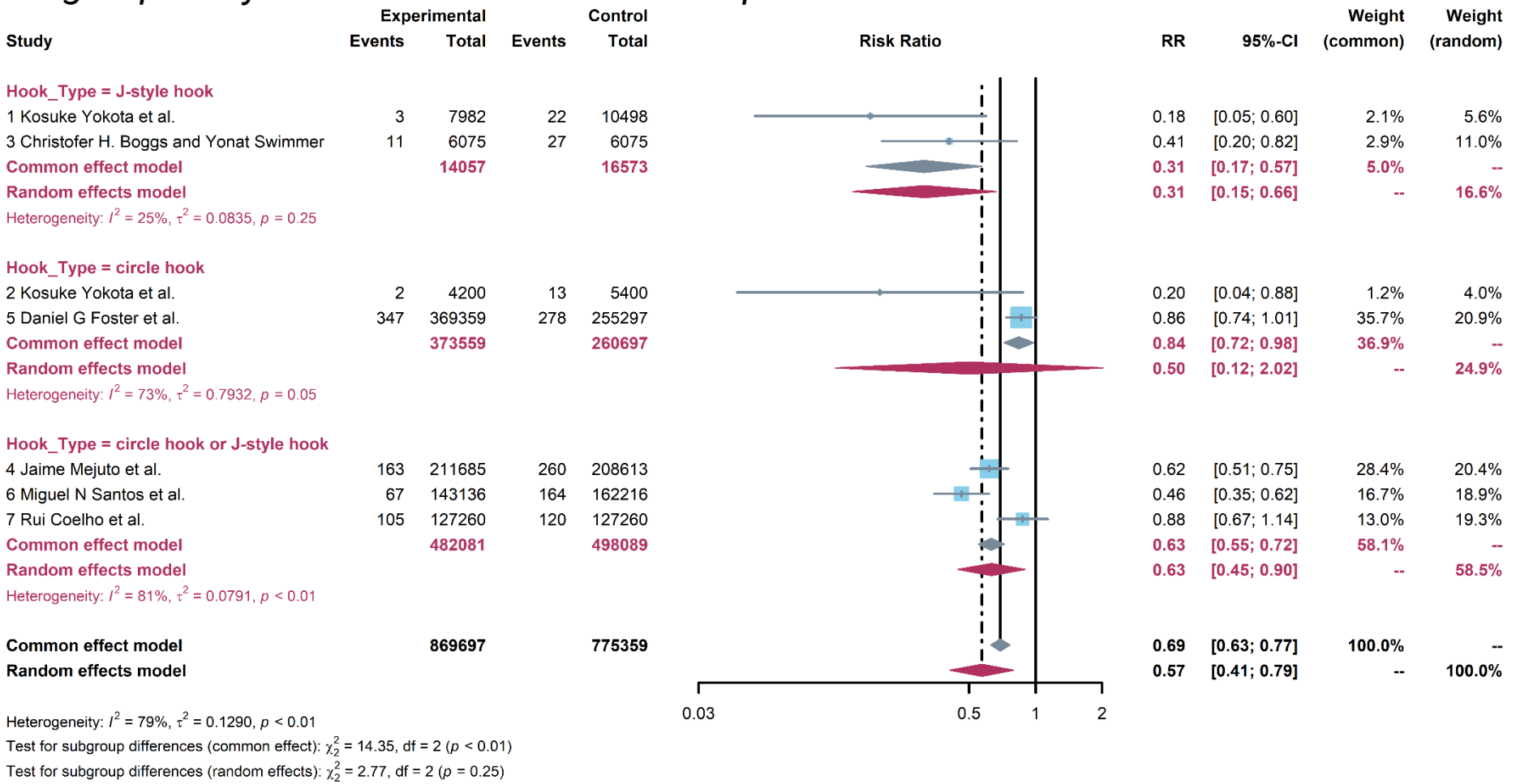
- *RR = 0.56*
- *Significant reduction*
- *Regional differences (Atlantic Ocean V.S. Pacific Ocean)*



Sensitivity analysis of olive ridley

Fish bait effects

- *Risk Ratio (RR) = 0.57*
- *significant reduction*
- *Subgroup analysis shows J-hook + fish bait performs better than circle hook + fish bait*



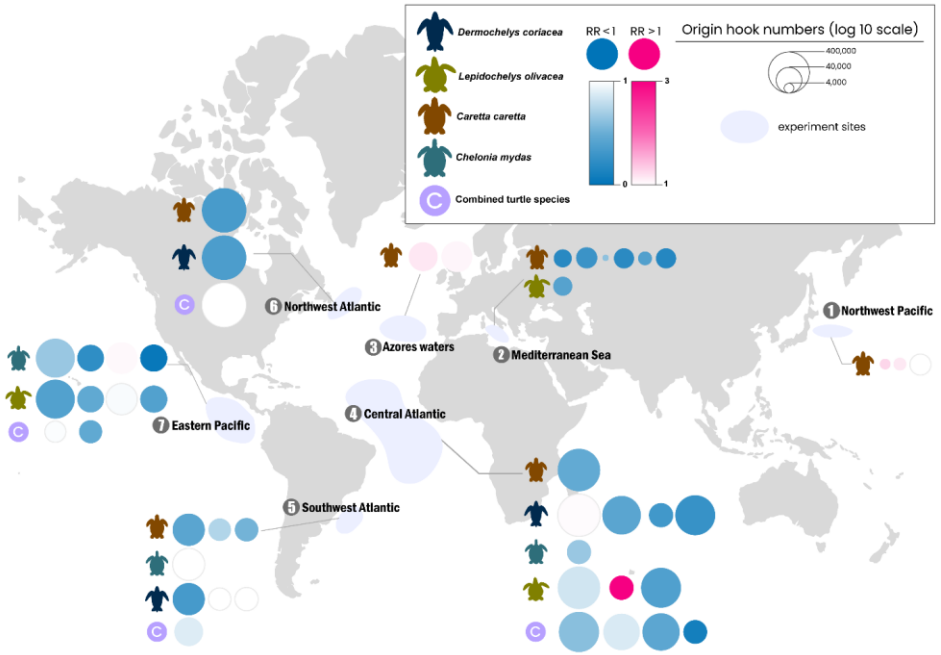
Subgroup analysis of seven studies on bait (hook type)

Key findings

Meta-analysis results of target species after replacing J-style hooks with circle hooks

species	methods	RR (95% CI)	RR (95% CI) (CR2)
tunas	circle hooks	1.30 (0.93-1.81)	1.30 (0.88-1.91)
swordfish	circle hooks	0.83 (0.70-0.99)	0.83 (0.69-1.00)
sharks	circle hooks	1.15 (0.96-1.37)	1.15 (0.93-1.40)

- Circle hooks show no significant negative impact on tuna and shark catch
- responses to mitigation measures vary across region and species
- Circle hooks are generally effective for loggerhead turtle, olive ridley turtle and leatherback turtle
- Bait type demonstrates a stronger mitigation effect compared to hook type



Limitations

- High heterogeneity across studies (I^2 often>75%)
- Limited sample size for some species
- lump pelagic longlines together, limiting to separate shallow-set (swordfish) from deep-set (tuna)
- Oversimplified gear variables, especially failing to account for hook size

Thank you

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