A review of the effects of hook, bait and leader types on pelagic longline fisheries: comparing catches and mortality of target, bycatch and vulnerable species

2nd IATTC Sea Turtle Bycatch Mitigation and Circle Hook Workshop

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OBJECTIVES

- Summarize information on **circle hooks as a measure in reducing mortalities of unwanted species, without significantly affecting the catch rates and yields of the targeted species.**

- Consider other gear configuration modifications, namely **bait type** and **leader materials**.

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REVIEW ARTICLE

WILEY

A review of reported effects of pelagic longline fishing gear configurations on target, bycatch and vulnerable species

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Abstract

1. A meta-analysis of 40 publications totalling 59 experiments was undertaken to review and assess the effects of changing the hook (circle vs. J-hooks or tuna hooks), bait (fish vs. squid) and leader (wire vs. nylon) type on retention and at-haulback mortality rates of teleosts (tunas and billfishes), elasmobranchs and sea turtles caught on shallow-set and deep-set pelagic longline fisheries.
2. Circle hooks are a promising approach to mitigate the impact of pelagic longline fisheries on sea turtles, as they reduced sea turtle retention rates. The adoption of circle hooks would, however, also lead to a decrease in swordfish retention, the main target species of shallow-set pelagic longlines.
3. Using fish as bait resulted in lower retention rates of sea turtles, highlighting that option as an additional measure to further mitigate sea turtle bycatch. The bait type had non-significant effects on sharks, except for blue shark and shortfin mako, for which at-haulback mortality rates were significantly higher with fish bait.
4. The use of nylon leaders instead of wire leaders could serve as a conservation measure for sharks, as they reduced the retention of blue shark without adversely impacting the catches of swordfish. The results on the effect of the leader material types should, however, be interpreted with caution owing to the limited information available reporting on leader material effects.
5. When considering future research directions, priority should be given to experimental field work on the effects of leader material and on deep-set longlines. Evaluating the post-release survival of species should also be a priority.

KEYWORDS
bycatch mitigation, conservation, fisheries management, fishing mortality, meta-analysis, pelagic longline

OBJECTIVES

- Retention rates
- At-haulback mortality

- Hook type (J, circle, tuna)
- Bait (squid, fish)
- Leader (nylon, wire)

- Bony fishes (swordfish, tunas and marlins)
- Elasmobranchs (pelagic sharks and pelagic stingray)
- Sea turtles

Note: This study is looking at retention rates, as it is not possible to know the true total catch of the gear, due to the bite-offs that happen with some gear configurations, but the extent of which are not yet fully known.

METHODS

- Random effects **meta-analysis**, with calculation of the **Relative Risk (RR).**

$$RR = \frac{a\,i/n\,1i}{c\,i/n\,2i}$$

RR < 1.0 *indicates* ***lower retention/at-haulback mortality rate*** *for* ***treatment*** *compared with the control*

- Where (for the i^{th} experiment):
  - *ai is the number of specimens retained on experimental gear (e.g. circle hooks),*
  - *n1i is the number of experimental gear used (effort),*
  - *ci is the number of animals retained on control gear (e.g., J-hooks)*
  - *n2i is the number of control gear used (effort), for the analysis of retention rates.*

METHODS

- Random effects **meta-analysis**, with calculation of the **Relative Risk (RR).**

- Validation procedure:
  1. *Calculate and test heterogeneity values (I^2: between-study heterogeneity)*
  2. *Search and detect possible outliers*
  3. *Conduct an influence analysis*

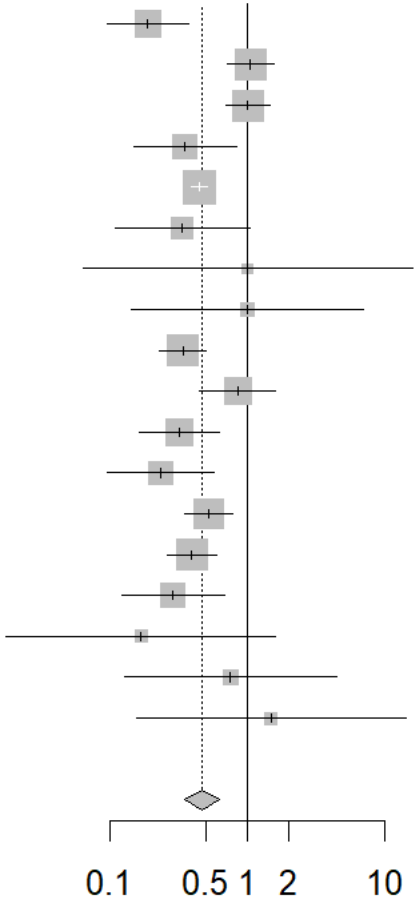
- Leave-One-Out-method: the meta-analysis is re-calculated K-1 times, each time leaving out one study (k=number of studies available).

EXAMPLE OF A META-ANALYSIS

Effect of changing from J-style to circle hooks on the retention of leatherback sea turtle

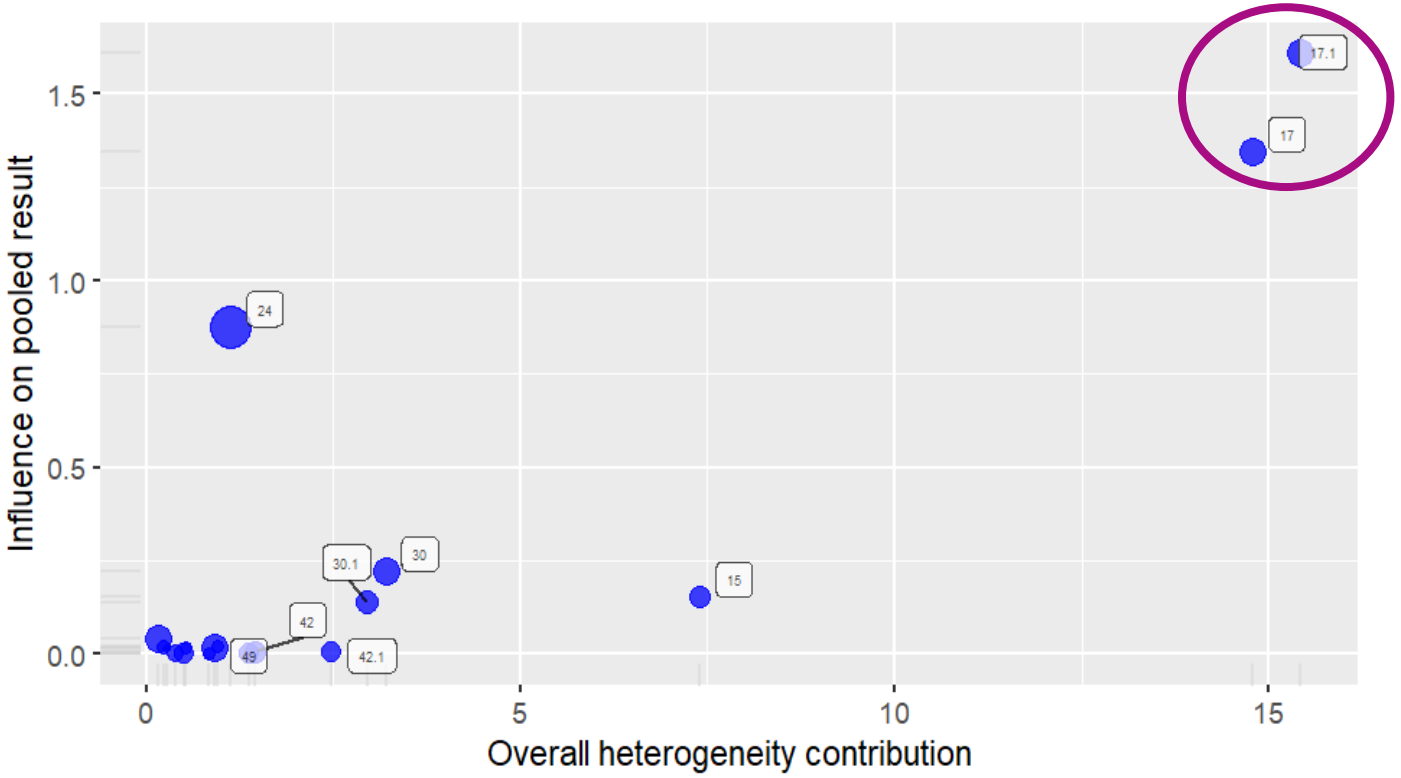
Experiment	Circle hook Nr. retained	Circle hook Nr. hooks	J-hook Nr. retained	J-hook Nr. hooks	Relative Risk	RR	95%-CI	Weight
15	11	2150674	35	1282748		0.19	[0.10; 0.37]	6.5%
17	74	138440	35	69173		1.06	[0.71; 1.58]	8.6%
17.1	84	147386	42	74300		1.01	[0.70; 1.46]	8.8%
20	7	72914	20	72914		0.35	[0.15; 0.83]	5.3%
24	323	5044540	455	3157102		0.44	[0.39; 0.51]	10.1%
25	4	25085	12	25085		0.33	[0.11; 1.03]	3.9%
27	1	22571	1	22571		1.00	[0.06; 15.99]	1.0%
28	2	19911	2	19911		1.00	[0.14; 7.10]	1.7%
30	34	255298	101	255297		0.34	[0.23; 0.50]	8.7%
30.1	40	369359	12	93780		0.85	[0.44; 1.61]	6.7%
42	14	108144	22	54072		0.32	[0.16; 0.62]	6.6%
42.1	7	95424	15	47712		0.23	[0.10; 0.57]	5.1%
48	47	84840	45	42420		0.52	[0.35; 0.79]	8.5%
48.1	40	84840	51	42420		0.39	[0.26; 0.59]	8.5%
49	8	148800	14	74400		0.29	[0.12; 0.68]	5.3%
49.1	1	148800	3	74400		0.17	[0.02; 1.60]	1.4%
52	3	14905	2	7465		0.75	[0.13; 4.50]	2.0%
52.1	3	14940	1	7395		1.48	[0.15; 14.27]	1.4%
Overall effect		**8946871**		**5423165**		**0.47**	**[0.35; 0.62]**	**100.0%**

Heterogeneity: I^2 = 69%, τ^2 = 0.2030, p < 0.01



Less with circle hooks ← → More with circle hooks

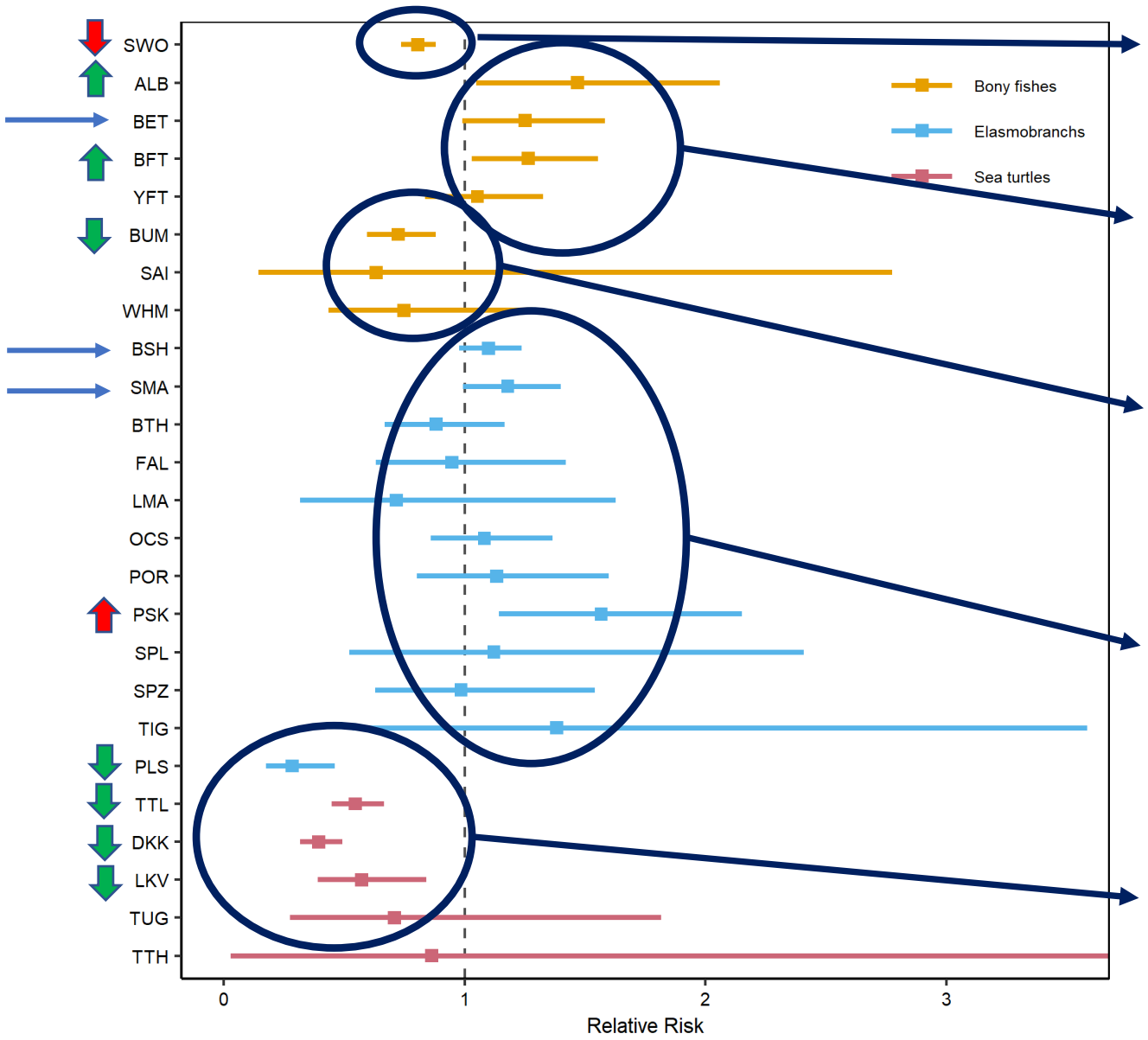
EXAMPLE OF A META-ANALYSIS




```
Identified outliers (random-effects model)
-------------------------------------------
"17", "17.1"

Results with outliers removed
-----------------------------
Number of studies combined: k = 16
Number of observations: o = 14370036
Number of events: e = 1571

                                RR           95%-CI     t  p-value
Random effects model 0.3945 [0.3168; 0.4912] -9.16 < 0.0001
Prediction interval         [0.2493; 0.6241]

Quantifying heterogeneity:
 tau^2 = 0.0346 [0.0000; 0.4001]; tau = 0.1859 [0.0000; 0.6325]
 I^2 = 30.3% [0.0%; 63.2%]; H = 1.20 [1.00; 1.65]
```

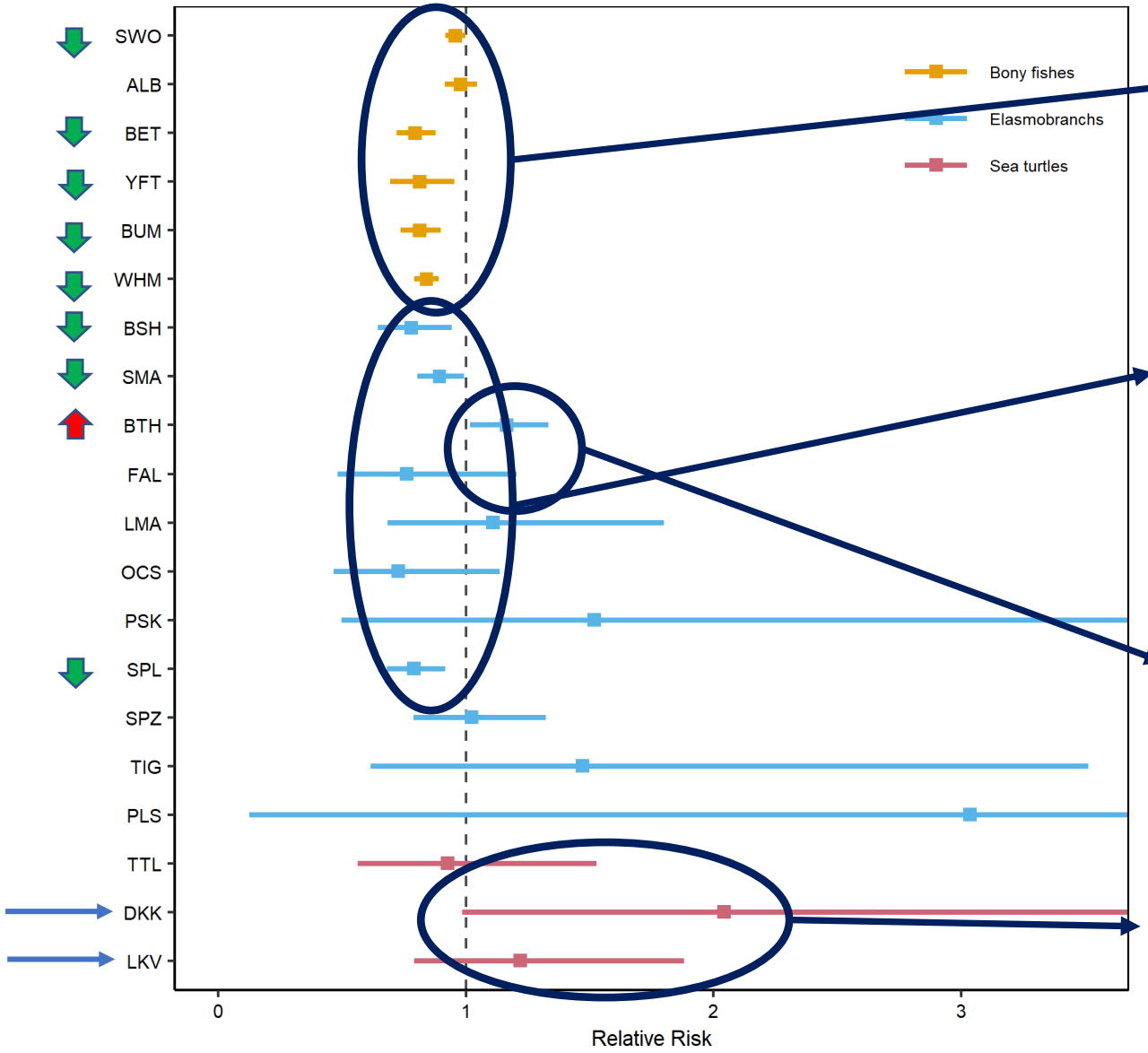
- Final Random Effects model RR = 0.39 (95% CI: 0.32 - 0.49)
- Reduction of 61% in leatherback sea turtle retention when using circle hooks compared to J-hooks, varying between 51% and 68% (at the 95% CI level)

RESULTS – Retention rates: Circle vs J-hooks



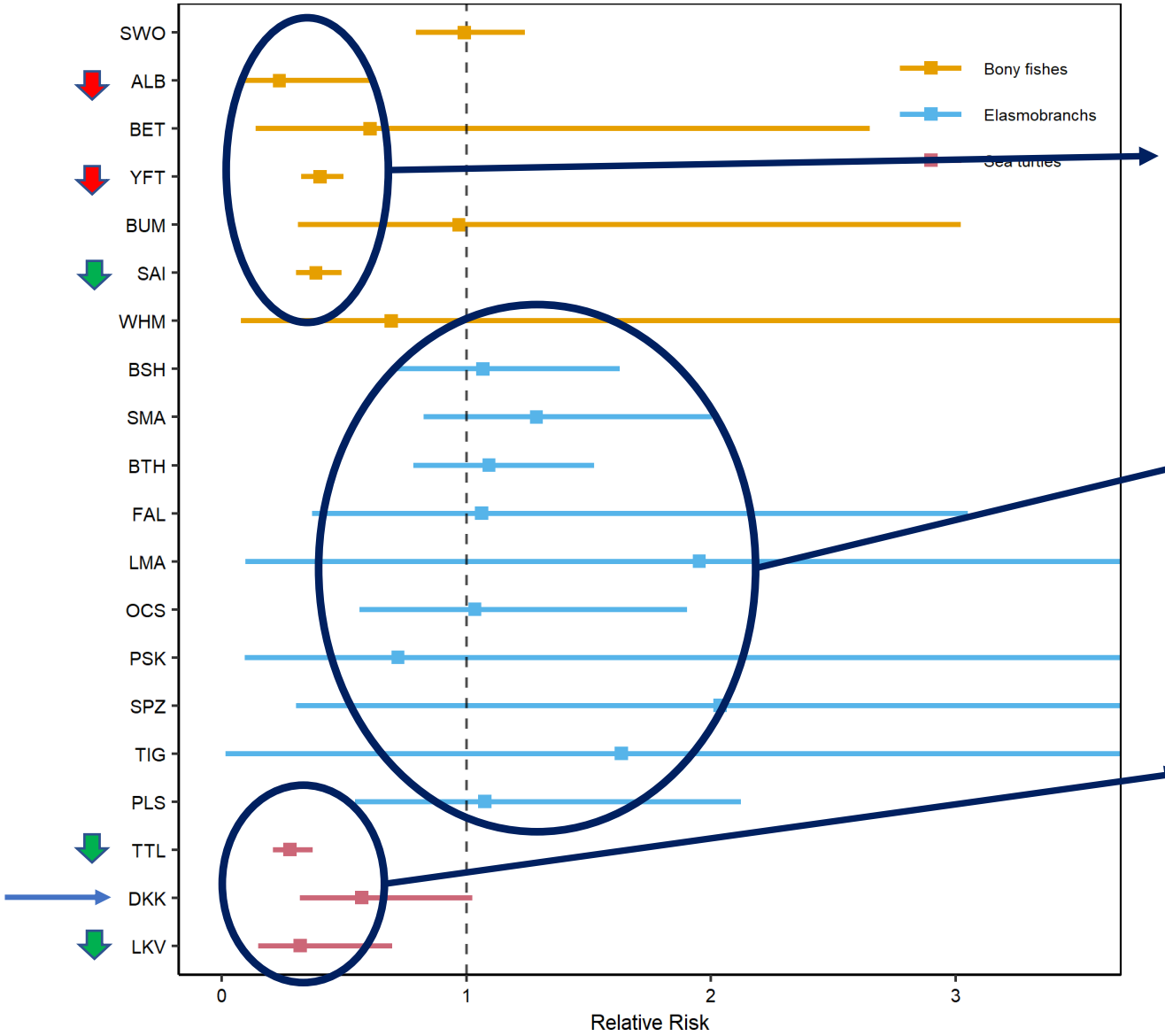
- **Swordfish** had **significantly lower retention** with **circle hooks** compared to J-hooks
- **Albacore** and **bluefin tuna** had higher **retention** with **circle hooks**. Also higher on bigeye tuna, but not-significant.
- **Blue marlin** lower **retention** with **circle hooks**. Other BIL also lower, but not-significant
- Several sharks with higher retention on circle hooks, close to significance for blue and shortfin mako. But only significant for the **crocodile shark.**
- **Loggerhead**, **leatherback** and **olive ridleys,** and **the pelagic stingray with significantly lower retention** with **circle hooks**.

RESULTS – At-haulback mortality rates: Circle vs J-hooks



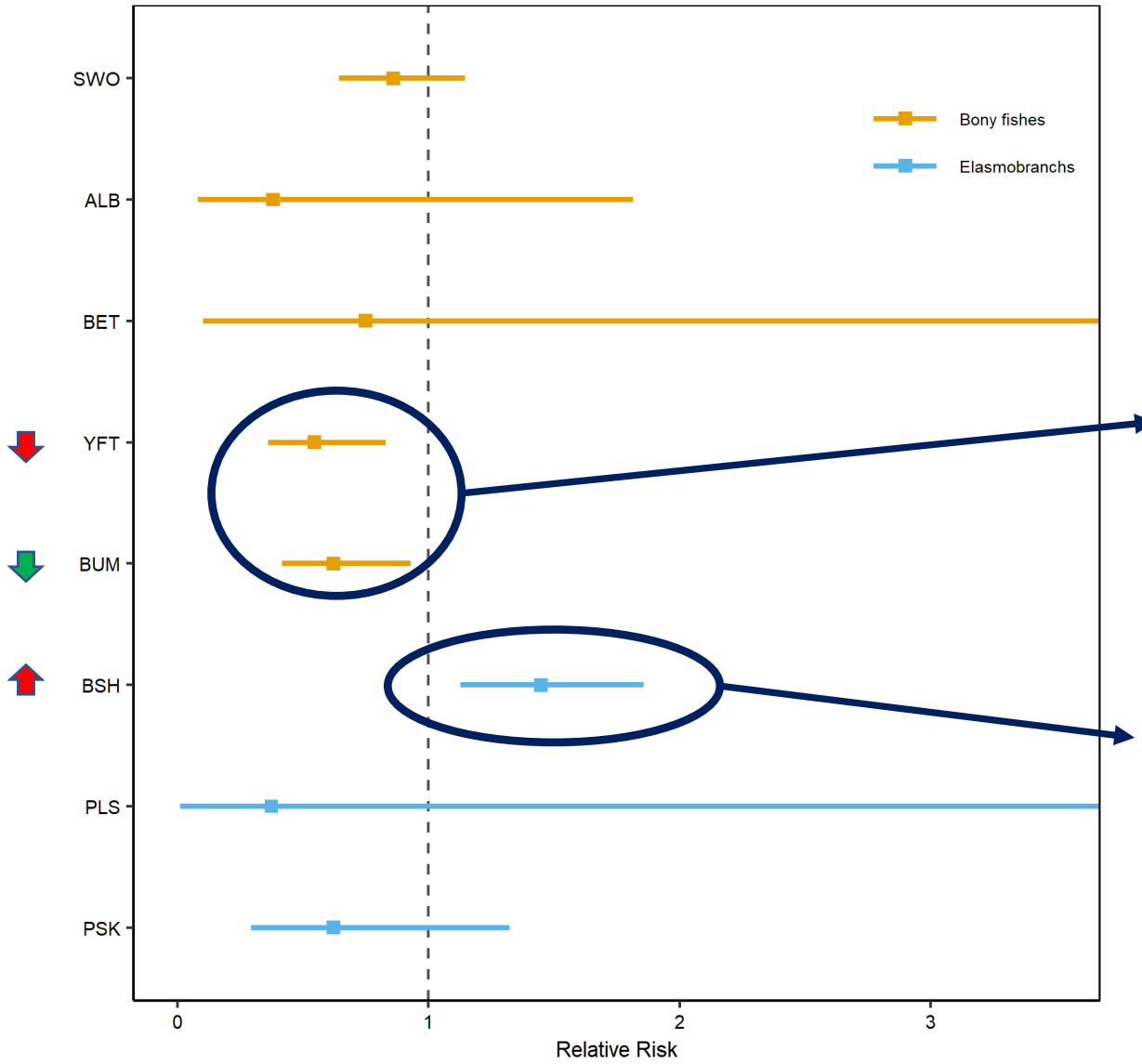
- **Swordfish, yellowfin, bigeye tuna, blue** and **white marlins** had **sig. lower at-haulback mortality** with **circle hooks.**
- **Blue shark, shortfin mako** and **scalloped hammerhead** also **lower at-haulback mortality** with **circle hooks.** Other sharks like silky and oceanic whitetip also lower, but not significant.
- The **bigeye thresher** had **significantly higher at-haulback mortality** rates when **circle hooks** were used instead of J-hooks.
- Circle hooks don't seem to reduce at-haulback mortality for **sea-turtles,** compared to J-hooks, possibly even increase on some species

RESULTS – Retention rates: Fish vs Squid bait



- **Yellowfin tuna, albacore** and the **Atlantic sailfish** had **significantly lower retention** rates when **fish bait** was used instead of squid.
- Bait does not seem to have any significant effects on retention of elasmobranchs
- **Loggerhead and olive ridley** had **sig. lower retention** when **fish bait** was used instead of squid. **Leatherback** was also lower, but not significant.

RESULTS – Retention rates: Wire vs Nylon leader

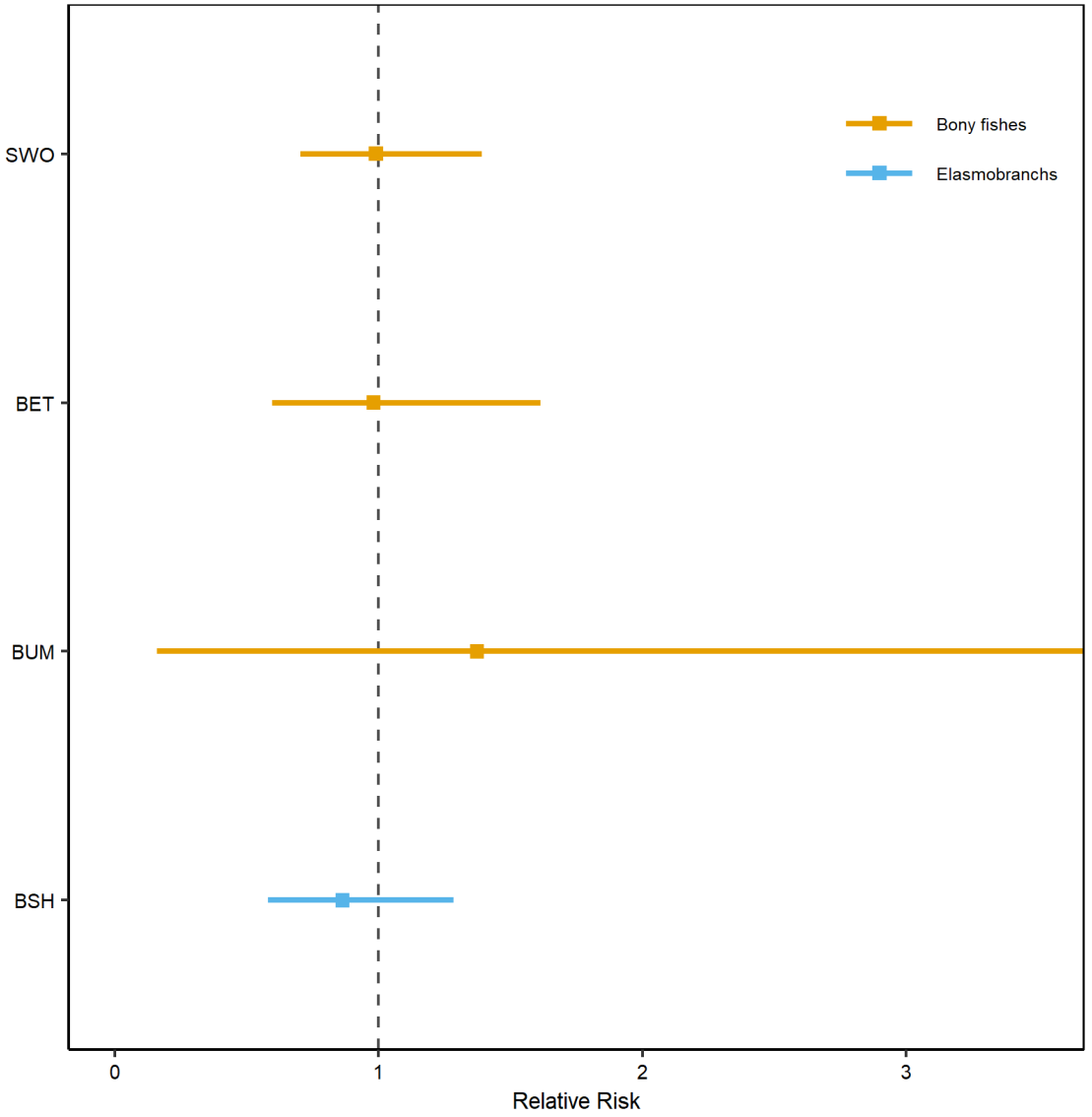


- **Analyses were much more limited** since far fewer studies reported on retention rates with different leader types**.**

- The **yellowfin tuna** and **blue marlin** had **sig. lower retention** when **wire leaders** were used instead of nylon leaders.

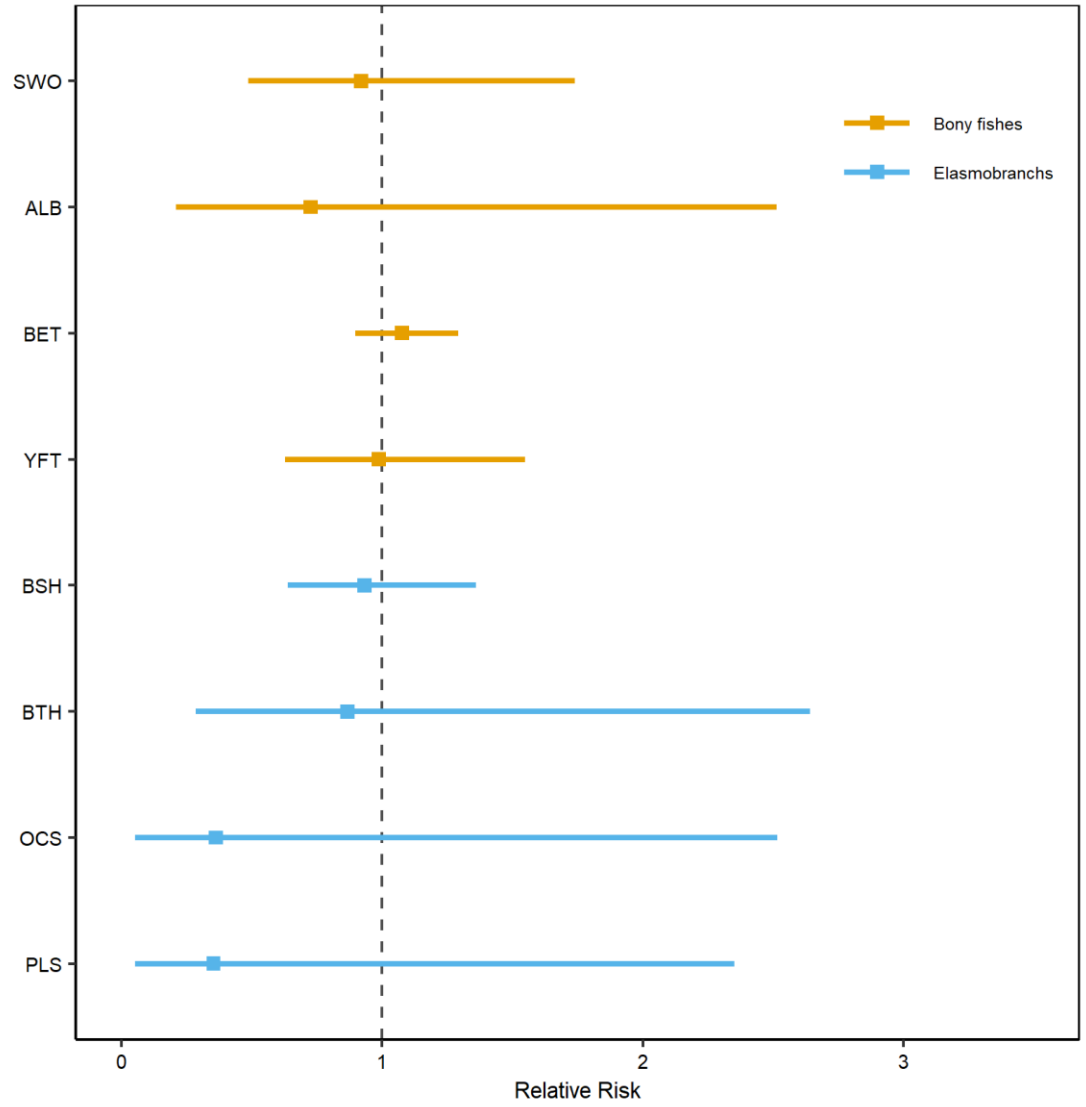
- For elasmobranchs, only **blue shark** had **sig. higher retention** rates when **wire leaders** were used.

RESULTS – At-haulback mortality rates: Wire vs Nylon leader



- **Very limited work done on at-haulback mortality comparing leader material.**
- **Blue shark, bigeye tuna, swordfish** and **blue marlin** were the only species with a minimum number of studies done to perform a meta-analysis.
- Overall, there are **no significant effects for any of the species** that have been studied **when changing from nylon to wire leaders**. Possibly due to lack of studies/power.

RESULTS – Retention rates: Circle vs tuna hooks (deep LL)



- **Limited studies on hook effects for deep setting longlines**.
- Only possible for some species, and mostly comparing circle vs tuna hooks.
- Overall, there are **no significant effects for any of the species** that have been studied **when changing from tuna hooks to circle hooks in deep setting longlines**. Possibly due to lack of studies/power.

DATA GAPS

	Shallow-set longlines								Deep-set longlines							
	Retention				At-haulback mortality				Retention				At-haulback mortality			
Species	Hook J	Hook T	Bait	Leader	Hook J	Hook T	Bait	Leader	Hook J	Hook T	Bait	Leader	Hook J	Hook T	Bait	Leader
SWO	25	6	7	3	11	6	4	3	2	5	0	0	1	2	0	0
BET	14	3	6	3	11	0	4	3	2	5	0	1	1	2	0	0
BFT	5	0	2	0	2	0	0	0	0	0	0	0	0	0	0	0
YFT	12	5	4	3	10	0	4	2	3	5	0	1	1	2	0	0
ALB	17	1	6	3	10	0	3	2	1	5	0	1	1	2	0	0
BUM	10	2	4	3	8	0	4	3	1	1	0	0	1	1	0	0
SFA	5	3	4	2	5	0	3	2	1	0	0	0	0	0	0	0
WHM	6	0	4	1	6	0	3	1	0	0	0	0	0	0	0	0
BSH	22	8	6	3	11	2	4	3	2	5	0	0	1	2	0	0
SMA	17	5	5	2	10	2	4	2	0	2	0	1	0	0	0	0
OCS	9	2	4	2	8	0	4	2	0	3	0	1	0	0	0	0
POR	5	0	2	1	2	0	0	0	0	0	0	0	0	0	0	0
FAL	8	4	4	2	7	0	4	2	1	1	0	1	0	0	0	0
BTH	7	2	5	2	7	0	4	2	2	3	0	1	1	1	0	0
LMA	6	1	4	1	4	0	4	1	0	1	0	0	0	0	0	0
PSK	8	1	4	3	8	0	4	2	0	2	0	0	0	0	0	0
SPL	7	0	2	0	3	0	1	0	0	2	0	0	0	0	0	0
SPZ	5	0	4	2	5	0	4	1	0	2	0	0	0	0	0	0
PLS	15	2	5	3	4	0	1	1	1	4	0	0	0	1	0	0
TTL	23	2	11	2	12	0	6	0	1	1	0	0	0	1	0	0
DKK	14	1	8	1	7	0	5	0	1	1	0	0	0	1	0	0
LKV	10	4	4	1	4	0	4	1	1	1	0	0	0	1	0	0
LKY	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
TUG	4	4	0	0	1	0	0	0	1	0	0	0	0	0	0	0

- There are more studies available for surface longlines, especially for factors such as hook type and bait, and far fewer for the leader materials.

- For deep setting longlines the gaps are more considerable.

MAIN CONCLUSIONS

- **The main results of our study are:**
  - **Sea turtle** interactions are **reduced with circle hooks, with even lower catch rates with fish bait**.
  - **Circle hooks tend to decrease at-haulback mortality of** a number of species, including some elasmobranchs such as **blue shark, shortfin mako** and **scalloped-hammerhead**.
  - **Circle hooks decrease retention of a main target species** (swordfish for shallow set LL), which results in an overall lower value of the retained catch.
  - **Nylon leaders reduce retention of blue shark.** Possibly also for other elasmobranchs, but still limited information to date.

- **Considerable heterogeneity** on most results. Need caution interpreting the results, and in general indicate the need for more and better designed studies.

- **Priorities for future studies** should be on **leader materials** and **deep-setting longlines**.

- Need to **estimate** the effects of hooks type and leader materials on **post-release mortality**.

ONGOING WORK – Subgroup on Technical Fishing Gear Changes

- Established in 2021. Reports to ICCAT Subcommittee on Ecosystems and Bycatch

- Main goals
  - 1): Collect, review and summarize past studies (e.g. reports and documents), with the main purpose to help inform design of Task 2 and 3.

  - 2): Designing experimental studies to assess the effects of terminal gear modifications (such as hook shape and size, leader type, etc) on catch rates, retention rates, at-haulback mortality and post-release mortality.

  - 3): Designing a study on the effects of fishing practices (e.g., timing, soaking time, bait, depths, areas) that could reduce bycatch and bycatch mortality

ONGOING WORK – Subgroup on Technical Fishing Gear Changes

- Power analysis of the effort needed to detect changes of 5%, 10%, 25% (with 80% probability) for hook types on retention
- Currently have data and calculations for various LL fisheries: **EU.PRT, TWN, USA, CAN, URY**

	Data										Power analysis		
Region	Fishery	Hook type	Gangion	Bait	Lightstick/ batteries	Fishing period	Depth	Species	N-catch	N-effort (hooks)	Delta	N_hooks (each combination)	N_sets (each combination)
Temperate NE Atlantic (>27N)	PRT	J	Mix	Mix	Y	Night	30-70m	SMA	554	612068	25%	277240	278
	PRT	J	Mix	Mix	Y	Night	30-70m	SMA	554	612068	10%	1732747	1733
	PRT	J	Mix	Mix	Y	Night	30-70m	SMA	554	612068	5%	6930987	6931
	PRT	J	Mix	Mix	Y	Night	30-70m	SWO	10323	612068	25%	14642	15
	PRT	J	Mix	Mix	Y	Night	30-70m	SWO	10323	612068	10%	91506	92
	PRT	J	Mix	Mix	Y	Night	30-70m	SWO	10323	612068	5%	366021	367
Tropical NE Atlantic (10N-27N)	PRT	J	Mix	Mix	Y	Night	30-70m	SMA	223	145742	25%	163900	164
	PRT	J	Mix	Mix	Y	Night	30-70m	SMA	223	145742	10%	1024368	1025
	PRT	J	Mix	Mix	Y	Night	30-70m	SMA	223	145742	5%	4097468	4098
	PRT	J	Mix	Mix	Y	Night	30-70m	SWO	1814	145742	25%	19929	20
	PRT	J	Mix	Mix	Y	Night	30-70m	SWO	1814	145742	10%	124552	125
	PRT	J	Mix	Mix	Y	Night	30-70m	SWO	1814	145742	5%	498207	499
	PRT	J	Mix	Mix	Y	Night	30-70m	BUM	39	145742	25%	938350	939
	PRT	J	Mix	Mix	Y	Night	30-70m	BUM	39	145742	10%	586468	5865
	PRT	J	Mix	Mix	Y	Night	30-70m	BUM	39	145742	5%	23458733	23459

- Long table with >300 lines... **Synthesize, so it is useful for information/planning purposes**
- **Add power-analysis related with mortality**

Thank you!