

## Supplementary Material

### 1 Supplementary Data

#### 1.1 Focus group discussion

Focus group discussion (FGD) were held in the Asociación de Pescadores Artesanales de la Tercera Edad building in San Jose, Lambayeque, Peru (6°46' S, 79°58' W) during field surveys from 1 July to 30 September 2017. FGD were facilitated by two researchers, one of whom was from Peru and whom was experienced in working with coastal fishers along the nation's coastline. The FGD estimating the San Jose inshore gillnet fleet's geographic extent comprised 14 males and 1 female. Respondent age ranged from 22-58 years. Fishing experience for skippers ranged from 5-46 years. The FGD estimating the San Jose inshore/midwater fleet's geographic extent comprised 4 males and 1 female. Respondent age ranged from 27-50 years. Fishing experience for skippers ranged from 11-17 years. Respondents were provided with refreshments and food during the FGDs.

**Supplementary Table 1.** Respondent characteristics by focus group discussion (FGD).

Variable	Category	FGD 1	FGD 2
Occupation	Skipper	13	3
	NGO scientist	1	2
	IMARPE officer	1	0
Gender	Male	14	4
	Female	1	1
Age	18-25	1	0
	26-40	5	3
	41-55	8	2
	56-70	1	0
Years lived in San Jose	0-10	1	2
	11 to 20	0	0
	21-30	5	1
	31-40	2	2
	41-50	5	0
	51-60	2	0
Years fishing	0-10	4	2
	11 to 20	3	3
	21-30	3	0
	31-40	3	0
	41-50	2	0

## 1.2 Risk assessment

### 1.2.1 Methodology

We draw on a qualitative ERA methodology known as the consequence–likelihood (probability) matrix to assess the level of risk posed to turtle species captured in the San Jose gillnet fishery (Fletcher, 2014). The consequence–likelihood (probability) matrix methods were based on the Australian and New Zealand Standard Risk Analysis (Standards Australia, 2000; 2004) and adapted for use in fisheries management within Australia (Fletcher et al., 2003; Fletcher, 2005). The methodology is now one of the most widely used risk assessment frameworks in fisheries (FAO, 2012; Fletcher and Bianchi, 2014).

An important element of any qualitative risk assessment methodology is that each ranking made by the risk assessment expert panel is supported by an appropriate level of documentation to justify each of the risk levels selected (Fletcher, 2014). Here we provide additional details of the information used to assign risk rankings throughout the qualitative ecological risk assessment (ERA) process assessing potential risks and the associated impact on sea turtle species that are captured in the San Jose gillnet fishery (6°46' S, 79°58' W).

Sea turtle species assessed include the leatherback turtle *Dermochelys coriacea*, green turtle *Chelona mydas*, and olive ridley turtle *Lepidochelys olivacea*. The assessment of risk from each of the San Jose gillnet fleets was considered relative to each turtle species distribution and risk exposure through their respective East Pacific Regional Management Unit (RMU). We use RMU's as management units (Wallace et al., 2010a). We do not try to implement a full qualitative risk assessment in which all target, non-target, and environmental components of the fishery are evaluated.

Risk was assessed in terms of the relative impact from each of the San Jose gillnet fishing fleets (e.g., inshore, and inshore/midwater) compared with the potential impact posed to each turtle species throughout their respective East Pacific RMU (Wallace et al., 2010a). The analysis took into account how the biology and distribution of the species affected its susceptibility to overfishing and also whether the current management arrangements in our case study fishery, including compliance with rules and any effort/catch limitation methods, were working effectively or not (Fletcher, 2014).

### 1.2.2 Results

**Supplementary Table 2.** Known seasonal changes in San Jose gillnet fishery characteristics by fleet. Summer fishing season = December – May, Winter fishing season = June – November. Fleet number is based on field census data of actively fishing gillnet skippers in San Jose that was obtained in the winter fishing season of the year 2017. IMG = inshore/midwater gillnet fleet, IG = inshore gillnet fleet.

Fleet	Season	Geographic extent	Fleet vessel number
IMG	Summer	27000 km <sup>2</sup>	28
	Winter	31500 km <sup>2</sup>	18
IG	Summer	1200 km <sup>2</sup>	150+
	Winter	3700 km <sup>2</sup>	150

**Supplementary Table 3.** San Jose gillnet fishery characteristics by fleet. IMG = inshore/midwater gillnet fleet, IG = inshore gillnet fleet. Data is presented as mean  $\pm$  standard deviation (SD). IMG sample size = 18, IG sample size = 150.

Fleet	Days per trip	GRT	Boat length (m)	Net length (m)	Outboard motor (horse power)	Management restrictions (effective overlap)
IMG	7.5 $\pm$ 1.6	8.9 $\pm$ 2.4	9.1 $\pm$ 1.8	1729.6 $\pm$ 611.7	-	Some at-sea minimization (LEDs) and remediation (REM and post-capture handling workshops)
IG	2.4 $\pm$ 1.4	3.7 $\pm$ 1.1	6.3 $\pm$ 1.3	1027.3 $\pm$ 327.1	52.4 $\pm$ 11	No

**Supplementary Table 4.** San Jose gillnet fishery bycatch data by fleet. IMG = inshore/midwater gillnet fleet, IG = inshore gillnet fleet. BPUE data is presented as mean  $\pm$  standard deviation (SD). Observer data is sourced from a volunteer programme over August 2007–May 2019 observing ~1-4% of the IMG fleet.

Fleet	Turtle species	Estimated potential overlap (fishery/turtle)	Turtle bycatch evidence	BPUE per trip	Observed released without injury	Observed injured releases	Observed deaths
IMG	Green	100%	Alfaro-Shigueto et al., 2010; Alfaro-Shigueto et al., 2018	$0.71 \pm 1.98$	199	100	23
	Olive ridley	75%	Alfaro-Shigueto et al., 2010; Alfaro-Shigueto et al., 2018	$0.08 \pm 0.46$	24	0	5
	Leatherback	100%	Alfaro-Shigueto et al., 2007; Alfaro-Shigueto et al., 2010; Alfaro-Shigueto et al., 2018	$0.02 \pm 0.21$	6	6	1
IG	Green	100%	Alfaro-Shigueto et al., 2010; Alfaro-Shigueto et al., 2018	-	-	-	-
	Olive ridley	100%	Alfaro-Shigueto et al., 2010; Alfaro-Shigueto et al., 2018	-	-	-	-
	Leatherback	100%	Alfaro-Shigueto et al., 2007; Alfaro-Shigueto et al., 2010; Alfaro-Shigueto et al., 2018	-	-	-	-

**Supplementary Table 5.** Olive ridley turtle bycatch evidence throughout the Pacific East regional management unit (RMU) distributions. MEX = Mexico, GTM = Guatemala, HND = Honduras, SLV = El Salvador, NIC = Nicaragua, CRI = Costa Rica, PAN = Panama, COL = Colombia, ECU = Ecuador, PER = Peru, CHL = Chile, EPO = East Pacific Ocean.

Turtle species	RMU (Pacific East) distribution	Bycatch evidence throughout East Pacific RMU
Olive ridley	Baja California Sur Mexico to southern Peru, the eastern Pacific and northwest of Hawaii	MEX Koch et al., 2006; Ruiz-Slater, 2006; Sara, 2011
		GTM Cornelius and Robinson-Clark, 1986; Eckert and Eckert, 1997; Sara, 2011; Brittain et al., 2014; Brittain, 2016
		HND Sotelo, 2010
		SLV Sara, 2011
		NIC Gutiérrez, 2009; Sara, 2011
		CRI Araya, 2006; Sara, 2011; Whoriskey et al., 2011; Dapp et al., 2013
		PAN Sara, 2011
		COL Rojas and Zapata, 2006; Sara, 2011
		ECU Sara, 2011; Alfaro-Shigueto et al., 2018
		PER Alfaro-Shigueto et al., 2010; Rosales et al., 2010; Alfaro-Shigueto et al., 2011; Sara, 2011; Alfaro-Shigueto et al., 2018
		EPO Wallace et al., 2010b

**Supplementary Table 6.** Green turtle bycatch evidence throughout the Pacific East regional management unit (RMU) distributions. USA = United States of America, MEX = Mexico, GTM = Guatemala, HND = Honduras, SLV = El Salvador, NIC = Nicaragua, CRI = Costa Rica, PAN = Panama, COL = Colombia, ECU = Ecuador, PER = Peru, CHL = Chile, EPO = East Pacific Ocean.

Turtle species	RMU (Pacific East) distribution	Bycatch evidence throughout East Pacific RMU	
Green	Los Angeles south, sweeping down the coast of Chile and the Eastern Tropical Pacific out to 145 West	USA	Work and Balazs, 2002
		MEX	Koch et al., 2006; Ruiz-Slater, 2006; Sara, 2011; Mancini et al., 2012
		GTM	Eckert and Eckert, 1997
		HND	-
		SLV	Sara, 2011
		NIC	Sara, 2011
		CRI	López and Arauz, 2003; Araya, 2006; Sara, 2011; Whoriskey et al., 2011
		PAN	Sara, 2011
		COL	Rojas and Zapata, 2006; Sara, 2011
		ECU	Sara, 2011; Alfaro-Shigueto et al., 2018
		PER	Alfaro-Shigueto et al., 2010; Rosales et al., 2010; Alfaro-Shigueto et al., 2011; Sara, 2011; Alfaro-Shigueto et al., 2018
		CHL	Sara, 2011; Alfaro-Shigueto et al., 2018
		EPO	Wallace et al., 2010b; Seminoff et al., 2015

**Supplementary Table 7.** Leatherback turtle bycatch evidence throughout the Pacific East regional management unit (RMU) distributions. USA = United States of America, MEX = Mexico, GTM = Guatemala, HND = Honduras, SLV = El Salvador, NIC = Nicaragua, CRI = Costa Rica, PAN = Panama, COL = Colombia, ECU = Ecuador, PER = Peru, CHL = Chile, EPO = East Pacific Ocean.

Turtle species	RMU (Pacific East) distribution	Bycatch evidence throughout East Pacific RMU
Leatherback	From the tip of Baja California Mexico south to Chile, out to 135W	USA Work and Balazs, 2002; Carretta et al., 2004; Eguchi et al., 2017
		MEX Martínez et al., 2007
		GTM Sara, 2011
		HND -
		SLV -
		NIC Sara, 2011
		CRI Sara, 2011
		PAN -
		COL -
		ECU Zarate, 2006; Sara, 2011; Alfaro-Shigueto et al., 2018
		PER Alfaro-Shigueto et al., 2007; Alfaro-Shigueto et al., 2010; Rosales et al., 2010; Alfaro-Shigueto et al., 2011; Sara, 2011; Alfaro-Shigueto et al., 2018
		CHL Donoso and Dutton, 2010; Sara, 2011; Alfaro-Shigueto et al., 2018
		EPO Spotila et al., 2000; Wallace et al., 2010b; Wallace et al., 2013

**Supplementary Table 8.** Summaries of the management measures contained in each management strategy scenario evaluated. IMG = San Jose inshore/midwater gillnet fleet, IG = San Jose inshore gillnet fleet.

Characterization (controls)	Scenario 1 (status quo)		Scenario 2 (protectionist)		Scenario 3 (incentive-based)	
Avoidance	IMG fleet	IG fleet	IMG fleet	IG fleet	IMG fleet	IG fleet
Total gear switch						
Gillnets to trolling/potting	No	No	Yes	Yes	No	No
Minimization						
Effort restriction						
50% reduction in gillnet soak time	No	No	No	No	Yes	No
Spatial management						
MPAs (spatio-temporal)	No	No	No	No	Yes	Yes
Gear controls						
LEDs on nets	Yes	No	Yes	No	Yes	Yes
Remediation						
Post-capture survival improvements						
Best practice handling release workshops	Yes	No	Yes	No	Yes	Yes
Compliance and monitoring						
Remote electronic monitoring	Yes	No	Yes	No	Yes	Yes
Biodiversity offset						
Green bycatch (Pigovian) tax <sup>1</sup> proportional to the turtle bycatch mortality rate (bycatch/population size) on an eastern Pacific pelagic longline fishery - funds to secondary nesting site protection for turtles in Costa Rica e.g., leatherback, olive ridley	No	No	No	No	Yes	Yes

<sup>1</sup> A green bycatch (Pigovian) can be a double dividend tax, acting as both as an offset and minimization strategy. The tax minimizes bycatch by internalizing the external costs of bycatch (for both consumers and producers as part of the tax is passed up the supply chain, depending upon the price elasticities of demand and supply). The first dividend is the welfare increase (including conservation) from minimization through the bycatch tax and the second dividend, and an additional source of welfare increase (including conservation), comes from the offset (Squires et al. 2018).



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