Final Report 2009: Reducing Leatherback Sea Turtle Bycatch by Trinidad's Artisanal Fishing Industry.

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Issue/Background

The leatherback sea turtle is the 'blue whale' of the turtle world. As the largest turtle it can exceed 916 kg with a flipper spread of 2.5 meters (Morgan 1990). A completely oceanic animal, leatherbacks swim 10,000 km per year, circumnavigating entire oceans in the search for high concentrations of jellyfish (Benson et al. 2007; Eckert et al. 2006; Eckert 2006; James et al. 2005a; James et al. 2005b; Shillinger et al. 2010), its primary food (James & Herman 2001). Its role in open ocean ecosystems seems to be the control of jellyfish populations, and as we are learning in the Atlantic Ocean, such control is extremely important in protecting commercial fish species (Mills 2001). Nonetheless the leatherback is listed as Critically Endangered on both the IUCN redlist and by the Endangered Species Act of 1973. The largest and more serious threat to the leatherback throughout the Atlantic Ocean and arguably throughout the world, is the accidental capture of the species in coastal artisanal gillnet fisheries. Of the 51 million persons who fish for sustenance or livelihood 50 million are artisanal coastal fishers (Berkes et al. 2001). In Trinidad, which supports nesting by more than 10,000 leatherbacks each year (S. Eckert *in prep*), 3,000 gillnet entanglements occur annually (Lee Lum, 2006). Not only does this source of mortality threaten many years of successful sea turtle population recovery efforts, but the entanglement problem places a severe strain on the ability of artisanal fishers to operate economically.

In response to the problem of leatherback mortality in Trinidad, a National Consultation was hosted during February, 2005 by the Wider Caribbean Sea Turtle Conservation Network (WIDECAST) and the Ministry of Agriculture, Land and Marine Resources of the Government of the Republic of Trinidad and Tobago (Eckert and Eckert, 2005). Invited participants included stakeholders from the fishing communities in Trinidad and Tobago; non-government conservation organizations; inter-national fishing and conservation experts; and Trinidad and Tobago government natural resource management agencies. The outcome of the Consultation was a plan to undertake a series of investigations in bycatch reduction (Eckert and Eckert, 2005) using stakeholders (e.g. fishermen and sea turtle conservation project staff) to conduct the investigations with expert oversight.

In 2007 we undertook large-scale bycatch reduction experiments. Important to the logistic structure of the project was to involve all stakeholders, including fishers and local turtle conservationists working together. Vessels from north and east coast ports were contracted to compare the fishing effectiveness of traditional nets that normally fish from the surface to between 30 - 45 feet deep to those that fished only near the surface to depth of 15 feet. Research by Gearhart and Price (2003) in North Carolina, had shown that lower profile nets used in a bottom set flounder fishery significantly reduced unintentional sea turtle entanglement. Because a narrower profiled net tends not to billow in the current, we believed it likely that it would hang in the water column more stiffly and provide less opportunity for sea turtle entanglement. Also, by limiting fishing to the area of the water column with higher fish probability, we believed that this alternative would not significantly reduce fish catch.

In addition to experimenting with gillnets, we also introduced Trinidad fishers to modern trolling methods. While Trinidad coastal fishers have used trolling, it was not considered as cost effective as gillnets and thus is used only rarely. For this project we outfitted pirouges with trolling gear consisting of outriggers, planers, fish finders and bandit reels.

Results for 2007 were very promising. *Surface set gillnets reduced sea turtle bycatch by 32.2%.* Catch of the most valuable species of mackerel, Kingfish, increased. Costs of net repair showed that low profile nets had a two and a half-fold reduction in net repair costs due to both lower turtle entanglement rates and lower rates of damage. Fishers reported that turtles entangled in lower profile nets were far easier to untangle, and that there were a significant number of turtles that struck the net and "bounced out". *When these costs are factored into an economic comparison of the experimental low profile and control nets we estimated that fishers will average $499 (TT) per day using low profile nets as compared to $334 (TT) per day with traditional nets.* Average daily trolling daily income was calculated at $406 (TT) with no sea turtle bycatch.

At the conclusion of the 2007 field tests, fishers were presented with the results of the experiments and asked about their willingness to try new these new methods. All (100%) reported that the catch of leatherbacks poses a serious problem for their fishing; 90% reported that they would switch to fishing with shallow set nets (10% said they “might” switch); 90% said they would be willing to switch to trolling; and 70% said they would switch to new methods even if they had to bear “some” of the costs of the switch (20% more said they might switch depending on the cost).

For the 2008 leatherback sea turtle nesting season, we continued our work in trying to increase the reduction of turtle catch in the narrow surface nets by testing the effect of marker-light colors, as some fishers report differential turtle catch using different lights to mark their nets. We discovered that lighting did not have any effect on turtle catch rate, though ironically red lights significantly increased the value of fish caught. We also continued our trolling experiments to try and bring trolling income up to that of gillnets by testing alternate artificial bait sizes. While daily income of trolling exceeds that of traditional gillnets, our new experimental narrow gillnets provide higher income, but also higher sea turtle takes than trolling.

Project for 2009

Two projects were undertaken in 2009: validating the bycatch reduction effectiveness of low profile nets; and implementation of a trolling incentive program.

Validating the effectiveness of low profile nets

During our low profile net experiments of 2007, we compared catch rates of target and bycatch finfish species and turtle entanglement rates between nets constructed of 4.25-inch stretched mesh webbing 50 meshes deep (i.e. nets that will fish down from the surface to 5 meters in depth) and nets constructed of the same webbing 100 meshes deep. Our rationale for these tests was based on findings from 2006 that implied that most mackerel species reside in the upper 5 meters of the water column. By concentrating fishing effort in the upper 5 m of the water we hoped to maintain similar mackerel catch rates, but because the net was only half the depth of a traditional net we felt it would be less prone to billow or balloon below the surface and thus be less entangling to turtles. Our results seem to support this conjecture, as turtle catch was lower in the low profile nets by 68% (Eckert 2008). Unfortunately, as we worked on the analysis of the catch data, we recognized a fault in our experimental design. The 2007 experiments used a matched pair design with alternating panels of 50 and 100 mesh net in equal lengths. Such a design meant that while we fished equal lengths of experimental and control net, we were effectively only fishing ½ the amount (as measured by area) of 50 mesh net and thus some reduction of turtle catch might be expected in the 50 mesh net simply because there was less net in the water. For our calculations we therefore doubled the catch of turtles in the 50 mesh experimental net and estimated that there would still be 32.2% reduction in turtle entanglement. For 2009, our goal was to repeat the 2007 experiment but to use equal area experimental and control nets to validate our previous calculations of reduction in turtle entanglement and to increase our sample size.

Creating incentives to move fishers into trolling as a bycatch reduction method.
Fishers are highly supportive of the program to develop bycatch reduction methods, and uniformly in favor of changing fishing techniques. However, we have not seen more than a few fishers actually adopt trolling, despite our data that demonstrate its economic parity with traditional surface gillnets. For 2009, we planned to institute an incentive program by offering gillnet fishers the opportunity to "trade in" their nets in exchange for trolling equipment and training on how to use it. Their nets would be stored for them until Oct. 1 when most leatherbacks have left the waters of Trinidad. At that time we promised to return the fisher's nets and allow them to keep the trolling gear. Along with our requirement that the fishers exchange their nets for trolling equipment, they were required to provide catch data so that we could continue to evaluate the performance of troll fishing.

Results

Four fishers were contracted to test experimental and control nets on the north coast of Trinidad. Two vessels operated from the Matelot fishing depot and 2 from the Toco fishing depot. Each vessel was equipped with new 4.25-inch braided nylon "greenweb" nets arranged with a 100 m long panel of 100 mesh alternating with two, 100 m long 50 mesh net panels. Total length of net was 900m. Such an arrangement yielded equal square area of 50 mesh and 100 mesh netting. As in previous years, observers were contracted for each vessel to record turtle catch data, and release entangled turtles. All fish catch was tallied, identified to species and weighed with the fish catch kept separate between experimental and control nets. Per-pound value for each species caught and fuel consumption were recorded for each trip.

Fishers made 60 trips from each port (30 days fishing effort per vessel), with as many as 3 net sets (net deployed and retrieved) per trip. Total number of sets was 182, 78 by Matelot based vessels and 104 by Toco based vessels. Mean soak hours per set was 4.16 h (sd=1.4 h) and mean trip duration was 10.67 h (sd=2.9h). Mean soak time was statistically different between fishers operating from Matelot and Toco (Student's 't'-test, p=0.003622) with a mean of 4.5 h for Matelot and 3.9 h for Toco vessels. Mean fuel consumption for all vessels was 8.56 (sd=3.32) gallons per trip. However, mean fuel consumption was statistically different between ports (Student's t-test, p=0.00) with fuel consumption at Matelot ($\bar{x}$ = 5.88, sd = 1.39) approximately ½ that of Toco ($\bar{x}$=10.57 gallons, sd = 2.91).

Catch Composition

Total number of species caught was slightly lower for the experimental nets (13 vs 15) when compared to the control nets (Table 1a & 1b). Total fish (by weight) caught in the experimental nets was statistically lower for Matelot (paired t test, $p = .0080$), but not for Toco ($p=0.0501$) (Table 1c). Catch of target species (Mackerel spp.) followed the same pattern with vessels fishing from Matelot showing a greater reduction in target species catch. Most of the catch difference seems to have been due to the reduction in biomass of target species rather than all other species (Table1c).

Table 1 – Catch composition for surface drift-gillnet fishing vessels operating from 2 fishing depots on the north coast of Trinidad and comparing catch rates of 100 mesh deep (control) with 50 mesh deep (experimental) nets of equal surface area.

a) *Fishers operating from Matelot (2 boats, 60 trips, 78 sets).*

Control

Common Name	Scientific Name	Biomass (lbs)	% Biomass	Number	% Number
Serra Spanish mackerel	*Scomberomorus brasiliensis*	1,498	34.77	447	25.85
King mackerel	*Scomberomorus cavalla*	858	19.91	139	8.04
Bonito	*Euthynnus alletteratus*	675	15.67	205	11.86
Brazilian sharpnose shark	*Rhizoprionodon lalandii*	326	7.55	192	11.10
Atlantic bumper	*Chloroscombrus chrysurus*	253	5.87	554	32.04
Ladyfish	*Elops saurus*	207	4.80	48	2.78
Crevalle jack	*Caranx hippos*	193	4.48	37	2.14
Stingray	*Dasyatis spp*	92	2.14	1	0.06
Coco sea catfish	*Bagre bagre*	71	1.65	29	1.68
Hammerhead shark	*Sphyrna tiburo*	36	0.84	19	1.10
Wahoo	*Acanthocybium solandri*	26	0.60	1	0.06
Blacktip shark	*Carcharhinus limbatus*	19	0.44	5	0.29
Lookdown	*Selene vomer*	17	0.39	36	2.08
Bluefish	*Pomatomus saltatrix*	16	0.37	4	0.23
Jamaican Weakfish	*Cynoscion jamaicensis*	13	0.30	5	0.29
Palometa	*Trachinotus goodei*	3	0.07	2	0.12
Caitipa mojarra	*Diapterus rhombeus*	2	0.05	2	0.12
Whitemouth Croaker	*Micropogonias furnieri*	2	0.05	2	0.12
Cobia	*Rachycentron canadum*	2	0.05	1	0.06

Experimental

Common Name	Scientific Name	Biomass (lbs)	% Biomass	Number	% Number
Serra Spanish mackerel	*Scomberomorus brasiliensis*	884	26.11	260	16.95
King mackerel	*Scomberomorus cavalla*	770	22.76	98	6.39

Brazilian sharpnose shark	*Rhizoprionodon lalandii*	370	10.94	197	12.84
Atlantic bumper	*Chloroscombrus chrysurus*	317	9.37	658	42.89
Crevalle jack	*Caranx hippos*	155	4.58	36	2.35
Ladyfish	*Elops saurus*	90	2.66	27	1.76
Coco sea catfish	*Bagre bagre*	82	2.42	35	2.28
Stingray	*Dasyatis spp*	81	2.39	1	0.07
Blacktip shark	*Carcharhinus limbatus*	30	0.89	2	0.13
Bluefish	*Pomatomus saltatrix*	15	0.44	4	0.26
Palometa	*Trachinotus goodei*	13	0.38	4	0.26
Lookdown	*Selene vomer*	12	0.35	21	1.37
Hammerhead shark	*Sphyrna tiburo*	8	0.24	4	0.26
Caitipa mojarra	*Diapterus rhombeus*	4	0.12	3	0.20
White Mullet	*Mugil curema*	3	0.09	1	0.07
Whitemouth Croaker	*Micropogonias furnieri*	2	0.06	1	0.07

b) Fishers operating from Toco Fishing Depot (2 boats, 60 trips, 104 sets).

Control

Common Name	**Scientific Name**	**Biomass (lbs)**	**% Biomass**	**Number**	**% Number**
Serra Spanish mackerel	*Scomberomorus brasiliensis*	1,991	35.01	615	31.80
King mackerel	*Scomberomorus cavalla*	1,148	20.19	177	9.15
Shark	*Carcharhinidae spp.*	923	16.23	360	18.61
Crevalle jack	*Caranx hippos*	631	11.10	257	13.29
Bonito	*Euthynnus alletteratus*	611	10.75	191	9.88
Atlantic bumper	*Chloroscombrus chrysurus*	89	1.56	145	7.50
Ladyfish	*Elops saurus*	76	1.34	28	1.45
Lookdown	*Selene vomer*	69	1.21	108	5.58
Wahoo	*Acanthocybium solandri*	45	0.79	1	0.05
Atlantic leatherjacket	*Oligoplites saurus*	39	0.68	29	1.50
Bluefish	*Pomatomus saltatrix*	28	0.49	9	0.47
Jamaican Weakfish	*Cynoscion jamaicensis*	15	0.26	8	0.41
Bonefish	*Albula vulpes*	13	0.23	2	0.10
Palometa	*Trachinotus goodei*	6	0.11	3	0.16
Coco sea catfish	*Bagre bagre*	4	0.07	1	0.05

Experimental

Common Name	**Scientific Name**	**Biomass (lbs)**	**% Biomass**	**Number**	**% Number**
Serra Spanish mackerel	*Scomberomorus brasiliensis*	1,551	30.52	478	28.30

King mackerel	*Scomberomorus cavalla*	908	17.87	139	8.23
Bonito	*Euthynnus alletteratus*	898	17.68	309	18.29
Crevalle jack	*Caranx hippos*	495	9.74	196	11.60
Lookdown	*Selene vomer*	102	2.01	145	8.58
Ladyfish	*Elops saurus*	84	1.65	26	1.54
Bluefish	*Pomatomus saltatrix*	47	0.93	13	0.77
Atlantic bumper	*Chloroscombrus chrysurus*	34	0.66	48	2.84
Atlantic leatherjacket	*Oligoplites saurus*	20	0.39	19	1.12
Palometa	*Trachinotus goodei*	6	0.12	3	0.18
Jamaican Weakfish	*Cynoscion jamaicensis*	3	0.06	1	0.06

c) Summary

		Total Catch				***Target (Mackerel)***			
Port	N	Con	Exp	%Diff	p value	Con	Exp	%Diff	p value
Matelot	60	4,308.5	3,383.5	-21.5%	0.0080	2356.0	1,653.5	-29.8%	0.0015
Toco	60	5,686.0	5,079.5	-10.7%	0.1597	3138.5	2,458.0	-21.7%	0.0501

Catch Value

Catch value was calculated based on the weight of fish caught and the price per pound per species on the day the fish was caught. There was a decrease in the total money earned by fishers using experimental nets from Matelot but there was no statistically significant change in earnings between control and experimental nets for boats from Toco at α=.05 (Table 2).

Table 2 – Catch composition for surface drift-gillnet fishing vessels operating from 2 fishing depots on the north coast of Trinidad and comparing catch rates of 100 mesh deep (control) with 50 mesh deep (experimental) nets of equal surface area.

a) Matelot fishing depot (2 vessels, 60 trips, 78 sets)

Control			
Common Name	**Scientific Name**	**Value $ TT**	**% Value**
Serra Spanish mackerel	*Scomberomorus brasiliensis*	$9,688	50.42
King mackerel	*Scomberomorus cavalla*	$6,004	31.25
Brazilian sharpnose shark	*Rhizoprionodon lalandii*	$972	5.06
Crevalle jack	*Caranx hippos*	$665	3.46
Bonito	*Euthynnus alletteratus*	$484	2.52
Stingray	*Dasyatis spp*	$368	1.92
Atlantic bumper	*Chloroscombrus chrysurus*	$253	1.32
Wahoo	*Acanthocybium solandri*	$182	0.95

Ladyfish	*Elops saurus*	$117	0.61
Bluefish	*Pomatomus saltatrix*	$112	0.58
Hammerhead shark	*Sphyrna tiburo*	$108	0.56
Blacktip shark	*Carcharhinus limbatus*	$84	0.44
Coco sea catfish	*Bagre bagre*	$71	0.37
Jamaican Weakfish	*Cynoscion jamaicensis*	$63	0.33
Lookdown	*Selene vomer*	$17	0.09
Palometa	*Trachinotus goodei*	$12	0.06
Cobia	*Rachycentron canadum*	$ 6	0.03
Whitemouth Croaker	*Micropogonias furnieri*	$ 4	0.02
Caitipa mojarra	*Diapterus rhombeus*	$ 2	0.01
	Total Value	$19,213	
Experimental			
Serra Spanish mackerel	*Scomberomorus brasiliensis*	$5,757	40.59
King mackerel	*Scomberomorus cavalla*	$5,247	36.99
Brazilian sharpnose shark	*Rhizoprionodon lalandii*	$1,110	7.83
Crevalle jack	*Caranx hippos*	$545	3.84
Bonito	*Euthynnus alletteratus*	$399	2.81
Stingray	*Dasyatis spp*	$324	2.28
Atlantic bumper	*Chloroscombrus chrysurus*	$317	2.23
Blacktip shark	*Carcharhinus limbatus*	$150	1.06
Bluefish	*Pomatomus saltatrix*	$105	0.74
Coco sea catfish	*Bagre bagre*	$82	0.58
Palometa	*Trachinotus goodei*	$52	0.37
Ladyfish	*Elops saurus*	$47	0.33
Hammerhead shark	*Sphyrna tiburo*	$24	0.17
Lookdown	*Selene vomer*	$12	0.08
White Mullet	*Mugil curema*	$ 6	0.04
Caitipa mojarra	*Diapterus rhombeus*	$ 4	0.03
Whitemouth Croaker	*Micropogonias furnieri*	$ 4	0.03
	Total Value	$14,185	

b) *Toco fishing depot (2 vessels, 60 trips, 104 sets)*

Control			
Common Name	**Scientific Name**	**Value $ TT**	**% Biomass**
Serra Spanish mackerel	*Scomberomorus brasiliensis*	$21,688	47.62
King mackerel	*Scomberomorus cavalla*	$14,305	31.41
Shark	*Carcharhinidae spp.*	$4,615	10.13
Crevalle jack	*Caranx hippos*	$3,150	6.92
Bonito	*Euthynnus alletteratus*	$614	1.35
Wahoo	*Acanthocybium solandri*	$360	0.79

Atlantic bumper	*Chloroscombrus chrysurus*	$193	0.42
Lookdown	*Selene vomer*	$174	0.38
Jamaican Weakfish	*Cynoscion jamaicensis*	$70	0.15
Ladyfish	*Elops saurus*	$38	0.08
Palometa	*Trachinotus goodei*	$30	0.07
Atlantic leatherjacket	*Oligoplites saurus*	$19	0.04
Bonefish	*Albula vulpes*	$ 6	0.01
Coco sea catfish	*Bagre bagre*	$ 2	0.00
	Total Value	$45,546	
Experimental			
Serra Spanish mackerel	*Scomberomorus brasiliensis*	$16,639	44.33
King mackerel	*Scomberomorus cavalla*	$11,969	31.89
Shark	*Carcharhinidae spp.*	$4,667	12.44
Crevalle jack	*Caranx hippos*	$2,469	6.58
Bonito	*Euthynnus alletteratus*	$917	2.44
Bluefish	*Pomatomus saltatrix*	$470	1.25
Lookdown	*Selene vomer*	$228	0.61
Atlantic bumper	*Chloroscombrus chrysurus*	$67	0.18
Ladyfish	*Elops saurus*	$42	0.11
Palometa	*Trachinotus goodei*	$36	0.10
Jamaican Weakfish	*Cynoscion jamaicensis*	$15	0.04
Atlantic leatherjacket	*Oligoplites saurus*	$10	0.03
	Total Value	$37,531	

c) Summary

Port		***Total Catch ($USD)***				***Target (Mackerel)***			
	N	Con	Exp	%Diff	p value	Con	Exp	%Diff	p value
Matelot	60	$19,213	$14,185	-26.2%	0.0069	$15,692	$11,004	-29.9%	0.0013
Toco	60	$45,546	$37,531	-17.6%	0.0510	$35,993	$28,608	-20.5%	0.0619

Based on these values, the average income per set was $428.18 TT in Matelot and $798.82 TT at Toco. Labor for net repair costs for 2009 were $4,740.00 TT for damage to nets caused by turtles entangled. While the repair costs were not attributed to either the experimental or control net, this amount averaged over the number of sets equals a expense of $26.00 TT per set or $25.00 TT per turtle. Such expenses do not include a valuation for time lost while the net was being repaired or material costs.

Turtle Catch

A total of 186 turtles were entangled during 182 sets in 120 days of fishing effort (Table 3). Matelot based fishers caught 63 turtles in 78 sets while fishers operating from Toco fishing depot caught 123 turtles in 104 sets. Overall, mean catch rate was 0.2198 turtles per set in the control nets and 0.1209 turtles per set in the experimental nets. This difference was statistically significant (Students t test, p=.000410). However, for fishers based in Matelot the difference in turtle entanglement rate between control and experimental nets was not statistically significant in contrast to fishers based in Toco where the difference between catch rates in control and experimental nets was statistically significant.

Table 3 – Number of turtles caught by 4 surface drift gillnet vessels operating from 2 fishing depots on the north coast of Trinidad. Each vessel fished equal square areas of standard (100 mesh) and experimental (50 mesh) netting in paired trials. Student's t tests were used to determine if catch rates were statistically different between net types.

Port	***Number of turtles***	***Mean catch per set***		***Standard deviation***		***Number of sets***	***p value***
		Control	Exper.	Control	Exper.		
Matelot	63	0.1239	0.1453	0.3302	0.3651	78	0.125866
Toco	123	0.2917	0.1026	0.6624	0.3302	104	0.000008
All	186	0.2198	0.1209	0.5513	0.3480	182	0.000410

Distribution of fishing effort

Fishing effort of the vessels from Matelot and Toco was distributed along the north coast from Gran Tacaribe beach to Galera Point (Figure 1). The two vessels operating from Matelot tended to remain relatively near to Matelot, while the Toco vessels fished near Toco as well as extending to the west into the same areas as those fished by the Matelot vessels.

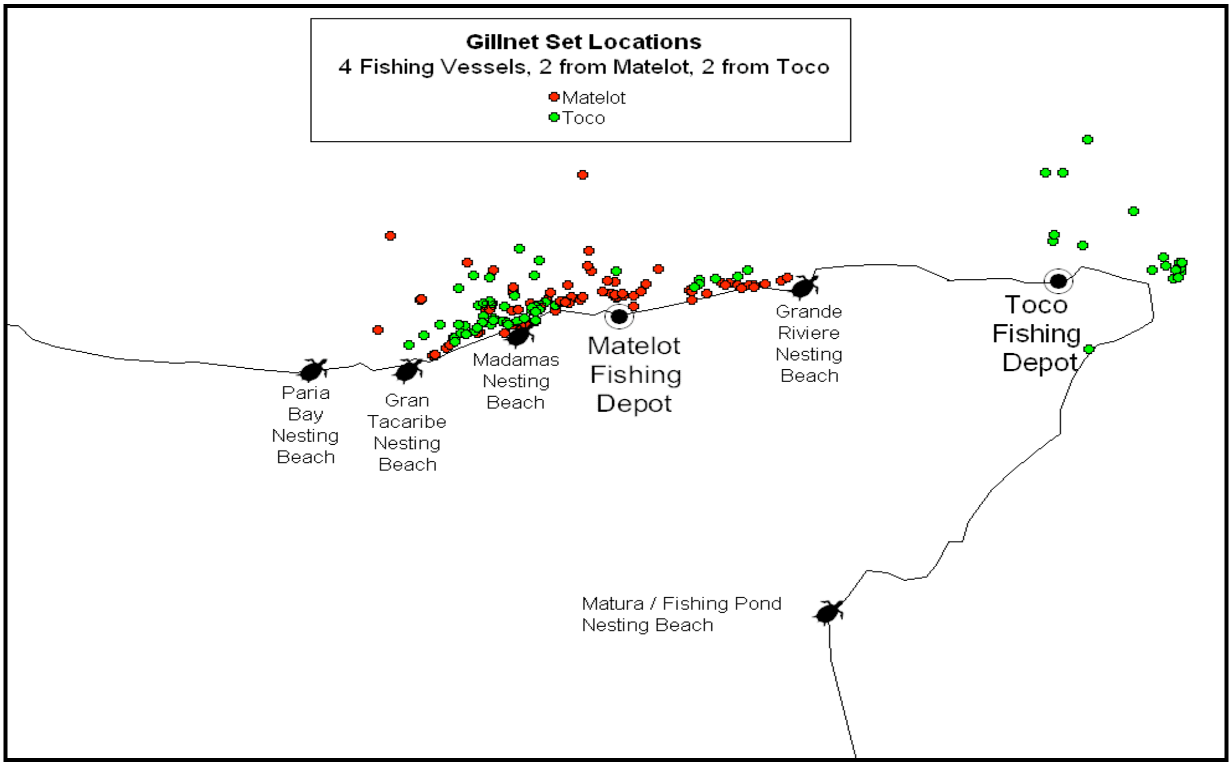

Figure 1 - Distribution of gillnet sets by 4 fishing vessels based at Matelot and Toco on the north coast of Trinidad. Sets are color coded to designate ports of origin for each vessel.

Nets are usually set in the evening with one end secured to the boat and drifted along the surface until retrieval 4 – 5 hours later. To evaluate the amount of water fished by the nets we calculated that average drift distance for each net set (i.e. distance between net deployment and retrieval). Mean distance drifted per set was 2.84 km (sd = 3.2, n=174). There was no correlation between distance traveled and soaking duration ($p>0.05$), nor between distance traveled or soak duration and number of turtles captured.

Discussion

A comparison in fish catch rates between experimental and control net types for 2009 was somewhat inconclusive because of differences in the results between the two ports. While Matelot based fishers showed a 21.5% reduction in overall catch and a concurrent 26.2% reduction in income with the experimental nets, Toco-based fishers showed a nominal 10.7% reduction in catch and a 17.6% reduction income which were not statistically significant and thus cannot be considered as a valid differences. Why Matelot fishers achieve different results in terms of the effective fishing capacity of the experimental nets when compared to Toco fishers using the same gear is unclear.

One possible explanation for the differences in fish catching performance of the experimental nets might be evaluated by reviewing where fishers from each port set their nets. We evaluated the catch rates based on areas fished for vessels operating from Toco and Matelot. Fishers working from Matelot tended to remain close to their port, which probably also explains why fuel consumption from this port was 50% less than Toco-based vessels. In contrast, Toco based vessels fished in two area, one near Matelot and closely overlapping the same area as Matelot fishers, but also in a second area nearer to Toco and around the Galera Point (Figure 1). We compared the mean total catch weight of fish caught per set around Galera Point (14 sets), to those around Matelot (166 sets) by fishers from both ports (Figure 2). There was no statistically significant difference in mean weight of fish caught per hour of net soaking time between fishers working from Matelot ($\bar{x}$ = 20.98 lb/h) or Toco ($\bar{x}$ = 25.92 lb/h) when fishing near Matelot (Students t test, p=.1798). However, fishers from Toco working around Galera Point caught more fish per hour, by weight ($\bar{x}$ = 39.73 lb/h). Such results seem to imply an area-effect on fish catch rates.

To determine if an area effect might have also influenced the difference in catch rates between experimental and control nets we evaluated whether the total weight of fish caught per trip was significantly different between experimental and control nets for Toco vessels fishing in waters near Matelot. There was no statistically significant difference in total weight of fish taken by the experimental and control nets (Students t test, p=0.411696) per trip for vessels operating near Matelot, irrespective of their port of origin. We are left to conclude that there is an unknown factor affecting the performance of the experimental nets exclusive to Matelot fishers. Given that Toco fishers working in the same area do not exhibit a reduction in catch with the experimental nets, it is not likely that the fishing area plays a role in this difference.

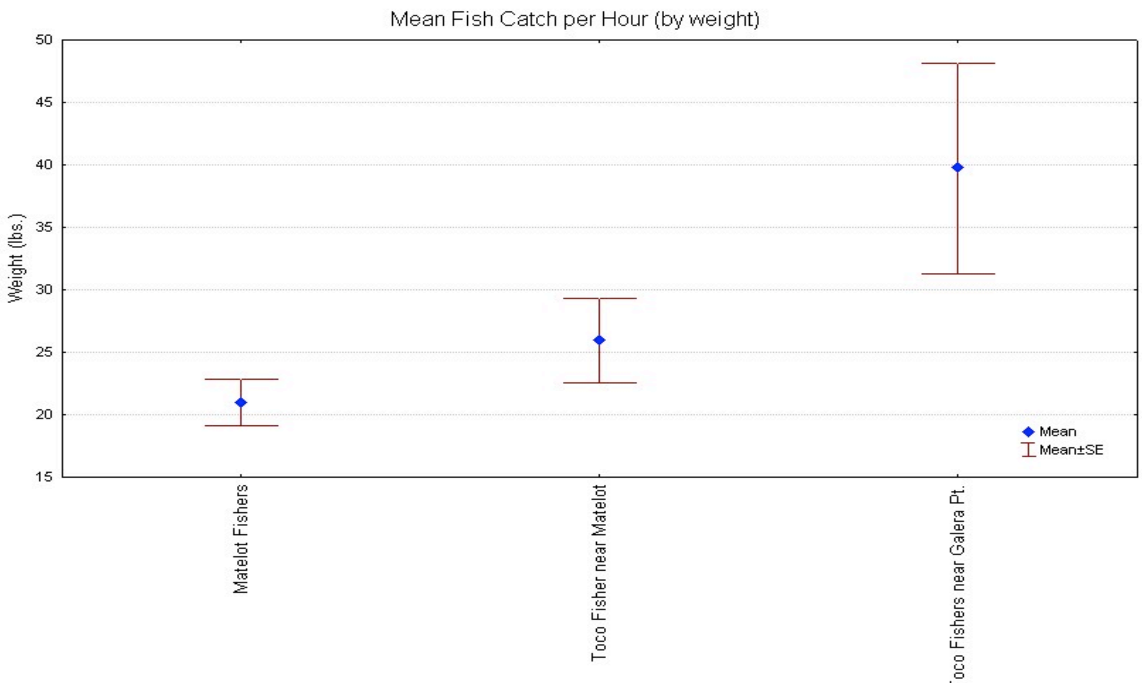

Figure 2 - Mean weight of fish caught per hour of soak time for fishers based in Matelot and fishing near Matelot (Matelot Fishers), fishers based in Toco and fishing near Matelot, and fishers based in Toco and fishing around Galera Point.

Similar to the conundrum posed by the differential fish catch between fishers operating from Toco and Matelot, the performance of the experimental nets in turtle entanglement were also different between Toco and Matelot fishers. Overall (e.g. all data combined), experimental nets caught significantly less (45.0%) turtles than control nets. However, there was no statistically significant difference in turtle entanglement rates (per set) between experimental and control nets for Matelot fishers, and there was a strong difference in turtle catch rate between control and experimental nets for fishers from Toco. As noted much of the Toco fishing effort was in the same general vicinity as fishing by Matelot fishers. We removed fishing sets by Toco fishers near Galera Point (Toco vicinity) and re-evaluated the difference in catch rates. In this case there was no significant difference in entanglement rates for turtles between experimental and control nets (Students t test, $p = 0.177$) for Toco fishers either. Experimental nets had a mean per set entanglement rate of 0.0617 ($sd = 0.242$, $n=81$) while control nets had an entanglement rate of 0.1235 ($sd = 0.331$, $n = 81$). Thus, it appears that there is an area effect on the catch efficiency of the experimental nets. While fishing near Matelot, experimental nets appear to be equally likely to entangle turtles.

Results of the 2009 experiments to test the effectiveness of using low profile 50 mesh (experimental nets), seem to indicate that such nets might reduce fish catch, but also significantly reduce see turtle entanglement. However, there are some very distinct area effects, in which the experimental nets were not effective in reducing turtle entanglement. This reversal appears most dramatic in the waters immediate to Matelot. The reason for this distinction is unclear. It is possible that the density of turtles is exceptionally high as the region around Matelot supports nesting by approximately 4,000 leatherback sea turtles. Further, it appears that fishers working in this area tend to remain closer to shore in presumably shallower water than fishers working in other areas. It may be that the effectiveness of the narrower net is defeated in shallow waters if its width extends from the surface to the bottom. Understanding where fishers work and how local environment impacts the effectiveness of low profile nets must be an important direction for future studies.

Gillnet Trade-in Incentive Program

The objective of this project was to develop an incentive program that would improve fisher's adoption of trolling during the nesting season. While fishers have been generally enthusiastic about finding new methods to reduce the levels of turtle entanglement, and highly cooperative in helping test new fishing techniques, we have found them slow to replace traditional 100 – 150 mesh nets with trolling methods. Yet, our previous research has demonstrated to the fishing community that trolling is 100% effective in eliminating leatherback sea turtle entanglement; has ½ the capital costs of gillnets and provides an equivalent level of economic return. While fishers have generally been aware of these results, there appears to be a number of reasons for resistance to a voluntary transition away from gillnets to trolling methods. Our previous tests showed that fishers in Trinidad have not typically used troll gear (though it is common use in Tobago) and such a lack of expertise means that the time between employment of trolling methods and economic return from its use can be long. In some cases fishers that tested trolling as part of our experimental tests would catch no fish for up to two weeks after starting to use the troll gear. Another concern by fishers is that costs of operation are higher, even though our data has demonstrated otherwise (e.g. fuel consumption is no different between typical gillnets and trolling per trip), such concerns are difficult for the fishers to overcome. Finally we have determined that gillnet fishers tend to approach fishing as a harvest activity, and are less focused on finding or hunting fish. They put far less effort into determining where fish might be, both in terms of geographic distribution and horizontal location than is needed when trolling. Trollers tend to "hunt" the fish school and develop sophisticated approaches to predicting where fish might be found.

We believe that much of the concern fishers express in the use of trolling gear could be resolved with training and if fishers could be convinced to use the gear for a period of time. Toward that end, this project was designed to provide gillnet fishers with the opportunity to receive training and to use trolling methods for the duration of the sea turtle nesting season from March – August. Each fisher that agreed to participate would receive up to a week of training; their boat equipped with trolling equipment including outriggers, a bandit reel, fish finder/sonar and all lines and artificial baits. In exchange they were asked to turn in their nets for storage to us. If they completed the season using trolling, their nets would be returned and they could keep the trolling equipment. If they chose not to complete the season, we asked that the trolling gear be returned and we would return their gillnets.

Results

Funding delays caused some unanticipated and rather significant problems with the implementation of this program. Instead of initiating the project in March as hoped, we were unable to begin the project until July when funding became available.

Project initiation began with the deployment of a training boat from Salybea fishing depot. This vessel was outfitted with a complete set of troll gear. To train fishers we hired a trolling specialist from Eastern Carolina University with the intention that he would assist our local coordinator with equipping troll vessels and provide the initial training of participating fishers as well as our local program coordinator.

However, in contrast to March when turtle entanglement rates are extremely high and fish catch relatively low, by July fishers were in the midst of one of the most successful kingfish seasons in recent memory and were catching large quantities of fish. Since turtle/gillnet interactions drop significantly in June, fishers were also catching very few turtles. The resulting combination of high fish catch and low turtle catch meant that fishers were not anxious to adopt new fishing methods. The 8 fishers that had earlier agreed to participate in our program withdrew. Three other fishers (one on north coast in Matelot and 2 on the east coast at Salybea and Balandra) agreed to try trolling and were extremely enthusiastic. However, after initial training and 3 weeks of fishing, 2 of these fishers returned their gear concerned that they were not catching as much fish as their gillnet colleagues. The remaining fisher in Balandra Bay continues to use his trolling equipment.

Because it was clear that fishers were not anxious to join a program that required them to turn in their gear when fishing was good and turtle entanglements were low, we put our resources into providing troll training for any fishers interested in participating. We held a series of 1 and 2 day training sessions in which fishers could learn how to outfit a boat with troll gear and spend 1 or 2 days on out training boat fishing with either our University of Eastern Carolina instructor or our local coordinator. By the end of 4 weeks over 30 fishers had participated in the training program. We also provided troll gear to one boat in each of 3 fishing depots with fishers who we felt they would continue to use the gear, without the requirement of exchanging nets for the gear.

Post-Season Fisher Interviews

To review fisher attitudes toward the bycatch response project we sponsored a senior biology student of Principia College (Luisa Gomez) to conduct fisher surveys in March of 2010 as part of her senior capstone thesis (Gomez, 2010 Senior Capstone Thesis, *in review*). Gomez interviewed 23 fishers from five fishing depots, Matelot, Toco and Grande Riviere on the north coast, Salybea, and Balandra Bay on the east coast over a 2 week period in early March 2010. Interviews were structured using a 4 page, 40-question survey covering details about the size and type of fishing gear (nets) used, preferred fishing methods, as well as impressions about the progress being made in the bycatch reduction project and attitudes about leatherback sea turtles.

Of the fishers interviewed, Gomez (2010) reported that 52% of the fishers were boat owners, but not necessarily owner/operators. Of those "most" were actively interested in using 50 mesh nets as the 2010 turtle-nesting season began. Interestingly non-owner operators (and crew) had little interest in 50 mesh nets as 80% of them reported that they preferred fishing nets deeper than 100 meshes. Gomez proposes that the reason for this difference lies in how boat revenues are shared. The gross revenue for each boat is divided into 5 shares. The boat owner gets 2 shares from which fuel, maintenance and net repair costs are paid, and the crew divides the remaining 3 shares. Thus, boat crews are primarily motivated by gross revenue, while the owners are motivated by net revenues. Gear repairs are deducted from the owners shares, so crew are less concerned about gear damage than owners. Also since the boat operator chooses the gear for each day's fishing, the owners have little influence over gear selection. Finally, Gomez also notes that fishers readily acknowledge that net fishing has the highest capital costs of all fishing methods.

Of the 23 fishers interviewed, 2 suggested that they would be switching to 50 mesh nets this turtle season to reduce leatherback entanglement. Gomez reports that 90% of all fishers noted that they intended to switch to bottom-set longline (locally known as "palangue") fishing during the 2010 leatherback nesting season. Such fishing primarily targets dermersal species, particularly shark. She also records that 87% of all fishers interviewed typically use multiple gear types during the year, depending on their effectiveness at catching fish.

In her research, Gomez also explored why fishers prefer gillnets and particular gillnet configurations. Some noted that they prefer to fish at night because it is cool and gillnets facilitate night fishing (braided nylon drift-gillnets are green in color, so are visible to fish in the daytime). In some cases fishers report that they can set nets in the evening and do not need to retrieve those nets until the morning. However, while Gomez does not report it, it is likely that such methods are reserved for bottom set gillnet fishers. Fishers also report a common idea that deeper set nets catch more fish varieties and thus more fish by weight.

Gomez concludes with a number of recommendations based on her results. One is the need for government to take a more active role in working with fishers to reduce bycatch. While fishers seem to appreciate the bycatch reduction research project, there is the impression that they will not adjust their methods without some regulatory structure emphasizing turtle conservation. There is clearly also a need for government or the Trinidadian fishing community to take a more active role in promoting improved fishing methods. As she notes, one fisher reported that if leatherback conservation were really important, government would already have taken action to do something about it. It is clear to the fishers that a lack of action on leatherback bycatch by the government agencies responsible for fisheries has implied a lack of necessity, and a lack of concern for this problem.

2009 Program Conclusions

The leatherback bycatch reduction program for 2009 provided valuable insight into the use of modified nets to reduce leatherback entanglement rates. It showed that low profile nets have the potential to significantly reduce entanglement rates, though possibly with some loss of fish. However, there also appears to be a geographic component to both the performance of the low profile nets and turtle entanglement, which should be resolved. Efforts to institute a trolling incentive program were not successful, in part due to a late start in the initiation of the project. However, the resulting training program in trolling methodology appeared to have great merit and seemed to improve fisher understanding of the use of modern troll methods. Continuing such training may actually prove to be the most effective tool toward moving some fishers toward a higher use of this turtle friendly methodology.

For the 2010 / 2011 nesting seasons we propose to work on two objectives. First, it is clear that a better understanding of the geographic influence on turtle catch and fishing effort is important. We will be proposing to implement a vessel monitoring system on boats that will enable us to better understand where fishers are operating, and where turtle interactions are highest. We will also work with government to develop a regulatory structure to improve the use of turtle friendly fishing methodology.

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